6.0 EFFECTS OF THE PROPOSED ACTION

6.1 INTRODUCTION AND METHODS

Effects of the action are defined as "the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with the action, that will be added to the environmental baseline" (50 CFR § 402.02). When project operations directly or immediately injure or kill fish or damage habitat at or near the project site, those are considered direct effects of the project. Indirect effects are defined in 50 CFR § 402.02 as "those that are caused by the proposed action and are later in time, but still are reasonably certain to occur." They include the effects on listed species of future activities that are induced by the proposed action and that occur after the action is completed. "Interrelated actions are those that are part of a larger action and depend on the larger action for their justification. Interdependent actions are those that have no independent utility apart from the action under consideration" (50 CFR § 402.02).

The approach to evaluating effects of the proposed action is summarized in Section 1.2 and detailed in Appendix D. The approach involved approximating the effect of the proposed hydro action as the difference between the effects of the proposed action and the "reference operation," a surrogate for the hydro portion of the environmental baseline that was described in Section 5.0. Then NOAA Fisheries quantitatively evaluated the effects of actions proposed to reduce or minimize those effects or to mitigate for them through non-hydro actions designed to improve habitat conditions and survival. Finally, NOAA Fisheries qualitatively evaluated the net combined effects of FCRPS operations and non-hydro improvements.

NOAA Fisheries then conducted two related analyses, one to inform the jeopardy determination and one to inform the critical habitat determination.

For the jeopardy analysis, as discussed in Section 1.0, NOAA Fisheries first determines whether the proposed action is likely to reduce the abundance, productivity, or distribution of a listed ESU. This analysis is conducted using both an evaluation of survival changes and, where survival data are lacking, a habitat proxy approach, as described in Section 6.1.1. If, in the jeopardy analysis, NOAA Fisheries determines that the proposed action is likely to reduce the abundance, productivity, or distribution of a listed ESU, then NOAA Fisheries must determine if that reduction constitutes an "appreciable reduction in the likelihood of both survival and recovery" and therefore is likely to jeopardize the continued existence of the ESU.

For the critical habitat analysis, NOAA Fisheries applied two alternative analyses. The first alternative, the "Environmental Baseline Approach," evaluates the effect of the proposed action on component areas of designated critical habitat and, in particular, on the essential features of that critical habitat comparing the conditions of the habitat with and without the proposed action. If NOAA Fisheries finds any alteration from the environmental baseline caused by the proposed action, it then determines whether the proposed action adversely modifies any of those essential features.

The second alternative analysis, the "Listing Conditions Approach," compares the conditions of the essential features of critical habitat that would exist under the proposed action and those conditions existing at the time the species were listed. If the proposed action would negatively alter those conditions from what they were at the time of listing, NOAA Fisheries would then determine whether that alteration is an adverse modification of critical habitat.

For this consultation, the effects of the proposed action on each ESU and on critical habitat are discussed in Section 6.0, while Section 8.0 presents NOAA Fisheries' determinations on whether the ESU effects constitute an appreciable reduction in the likelihood of both survival and recovery and the habitat adverse effects constitute destruction or adverse modification of critical habitat.

6.1.1 Methods for Evaluating Proposed Hydropower Operations and Configuration Changes

The effects of proposed FCRPS operations and configuration changes are first evaluated as differences in habitat conditions between the proposed operation and the "reference operation" described in Section 5.0 as a proxy for determining whether the proposed annual hydro operation results in less survival of listed fish. Habitat conditions that support a sufficient number and distribution of viable populations (i.e., populations with adequate abundance, productivity, spatial structure, and diversity) serve as a valuable proxy for a quantitative survival analysis. There is a strong causal link between habitat modification and the response of salmonid populations. Any differences in habitat condition (positive or negative) relative to the "reference operation" represents the effects of the proposed action. This evaluation of habitat effects supports the jeopardy analysis for all ESUs. Additionally, evaluation of the change in essential elements of critical habitat, as described in Sections 1.0 and 5.0, support the analysis of adverse modification of critical habitat for the three Snake River ESUs with designated critical habitat.

One or more populations of 11 of the 13 ESUs travel through one or more mainstem Snake and Columbia river FCRPS hydropower projects during their juvenile and adult migrations. For all of these ESUs, NOAA Fisheries is able to estimate the juvenile and adult survival rates[1] associated with the Action Agencies' proposed FCRPS operations and system configuration changes at each or a series of these projects, using the same "survival approach" applied in the analysis of the reference operation (see Appendix D). For several ESUs where empirical data are sparse or lacking, these survival estimates are inferred from data available for similar species (e.g., Snake River sockeye survival rates are inferred from SR spring/summer chinook and SR steelhead). This survival rate correlates to the aggregate of most of the known habitat effects occurring within the same reach, so this analysis provides an alternate evaluation to that performed using the habitat proxy approach.

NOAA Fisheries approximates the effect of proposed annual near-term (2004-2009), intermediate-term (2010-2013) and long-term (2014) hydro operations on fish survival during their migration through the FCRPS by determining the relative difference in the survival rates

[1] "Survival" estimates referred to in Section 6.0 are quantitative measurements of the number of fish surviving passage past a project (reservoir and dam). Juvenile survival estimates at the dam can be specific to a route such as turbine, juvenile bypass system, or spillway.

between each of the near-term, intermediate-term, and long-term proposed hydro operation and system configuration and the "reference operation" described in Section 5.0.

One reviewer of the September 9, 2004 draft of this Opinion suggested the effects of the proposed action and reference operation should be evaluated using absolute numbers of juvenile fish and that a pre-dam and post-dam survival analysis should be conducted. In general, NOAA Fisheries does not agree with using absolute numbers of juvenile fish in the analysis because solid data on the actual number of juvenile fish migrating each year, particularly between listed species, is unavailable, and determining a relative survival difference between two operations and system configuration changes is a better analytical approach because it can be compared with a relative survival change in any other life stage. However, as described in Section 5.2.2.3.1, estimates of in-river survivors are displayed in this Opinion for SR fall chinook salmon. This is because there is great uncertainty in estimating transport survival rates for this ESU and, without that information, weighting the influence of the in-river survival rate on the ESU is problematic. The number of in-river survivors and the difference in in-river survivors between the reference and proposed operations is informative because it may be possible to evaluate the effects on abundance of offsetting actions immediately downstream of the hydro system that affect the same life stage of SR fall chinook.

Concerning the comment about survival comparisons between pre-dam and post-dam survival rates through the FCRPS, free-flowing river (or pre-dam, historical) survival rates are presented for each listed species in Section 5.2.2.3.1.2 and can be compared to the current estimated survival rates (post-dam) identified in Table 6.5 in this section for the proposed action. As described in Section 5.2.2.3.1.2, information about free-flowing survival extrapolates selected information through a portion of the Snake River that does not have dams and assumes that, if no dams existed in the Columbia and Snake rivers, this rate of survival would continue throughout both rivers. It provides an estimate of in-river survival of fish without operations and without dams and other factors that affect these species during migration. This additional point of reference is informative for judging the significance of the mortality associated with the reference operation and the reduced levels of survival, compared to the reference operation, under the proposed action.

Where juvenile fish are transported in barges or trucks around FCRPS projects, NOAA Fisheries' estimates of their survival rates include the observed rate of survival to the point of release back to the river below Bonneville Dam. It also includes the effects of passage through the FCRPS beyond those effects experienced by non-transported juveniles that are delayed and therefore not expressed until after the fish are released downstream of Bonneville Dam (referred to elsewhere as the "D" value). Survival rates were estimated both as absolute differences between the proposed and reference operations and as relative (i.e., proportional) difference. Proportional survival differences were of primary interest, because these are most relevant for comparing with off-site measures that affect survival rates in other life stages (see the example in Section 6.1.3).

For purposes of the jeopardy analysis, the combination of survival and habitat effects is summarized as a categorical qualitative impact (e.g., Very Low, Low, Medium, High) on one or more VSP characteristics, according to criteria discussed in Appendix A. For purposes of the adverse modification analysis, the habitat effects are summarized and expressed as changes to the essential features of designated critical habitat.

Finally, reviewers of the draft version of this Opinion expressed concern about the detrimental effects on juvenile and adult migrants due to accidental releases of turbine lubricants, transformer oils and other hazardous substances at mainstem hydroelectric projects. NOAA Fisheries has become aware that Federally mandated plans for spill prevention, containment, and mitigation exist at each of the FCRPS projects, and the Action Agencies have agreed to make these plans available to NOAA Fisheries' Hydro Division.

6.1.2 Methods for Evaluating Proposed Non-hydro Actions

Methods for evaluating the effects of non-hydro tributary and estuary habitat improvements, reduction of avian predation, and effects of monitoring are detailed in Appendix E. Briefly, staff compared current population status (abundance [number of fish or redds] and productivity [survival rate through one or more life stages, e.g., recruits per spawner]) against estimates of historical population status as an indication of the capacity of the population to increase. Then, using available assessments of historical and current tributary habitat conditions, staff evaluated whether tributary habitat processes within the geographic area currently occupied by the population had been degraded or impaired. Based on assessments of tributary habitat, staff then identified those tributary habitat factors which, as a result of degradation or impairment, were considered most likely limiting to the anadromous salmonid population's abundance, productivity, distribution, or diversity. Finally, the first three steps were integrated to derive an estimate of the capacity of the population to respond to improvements in habitat condition. As a first cut, NOAA Fisheries ascribed qualitative rankings (Very High, High, Medium, Low, and Very Low) to population and habitat parameters, based on the magnitude of the observed or potential difference (see Table 6.1).

Table 6.1. Qualitative Categories for Potential Improvements in VSP Characteristics

Ranking	Description
"**Very Low**"	Little or no potential for improvement; very high risk that these activities would not result in any beneficial effects.
"**Low**"	Small potential for improvement, possibly on the order of a percentage or two relative change in survival rate or abundance (i.e., possibly up to 1.01-1.02 times the current survival rate or abundance level).
"**Medium**"	Significant potential for improvement in population status, perhaps as high as a 24% improvement in survival rate or abundance (i.e., up to 1.24 times current survival rate or abundance level).
"**High**"	Potential for improvement is high, possibly resulting in a doubling of survival rate or abundance (i.e., up to 2 times current survival rate or abundance level).
"**Very High**"	Potential for improvement is very high, possibly resulting in more than a doubling of the current survival rate or abundance level.

In order to evaluate the effect of the Action Agencies' proposed non-hydro program, NOAA Fisheries considered the requisite resources and authorities of the Action Agencies to evaluate whether the measures could be efficiently implemented or whether a proposed metric goal was likely to be met in a timely fashion. In addition, NOAA Fisheries examined the likelihood that implemented actions or obtained metric goals would effectively improve the viability of salmonid populations within the action area.

NOAA Fisheries evaluated the likely biological effectiveness of the Action Agencies' tributary habitat enhancement actions (identified in the proposed action either by project or proposed performance measures) in relation to factors identified as limiting listed salmonids within those subbasins. NOAA Fisheries also considered the effect of tributary actions implemented by the Action Agencies within the action area since 2000 when reviewing the degree to which the proposed action addressed the limiting factors identified in Appendix E and Fresh *et al.* 2004, the alternative analyses provided by the Action Agencies in their Updated Proposed Action, and other information, such as the Northwest Power and Conservation Council's subbasin plans. In evaluating short- and long-term benefits, NOAA Fisheries considered whether the action was already being implemented or was initially proposed in the Updated Proposed Action, and any anticipated lag between project completion and environmental response.

NOAA Fisheries also characterized the probable temporal lag between project implementation and biological benefit, depending on whether the action provided immediate benefits (e.g., entrainment) or benefits over a longer term (e.g., riparian revegetation). After considering the Action Agencies' commitment to implement non-hydro actions and the potential benefit of those actions to the magnitude and scope of significant limiting factors, NOAA Fisheries made qualitative conclusions on the likely benefit of the proposed actions on the viability of targeted populations.

The potential for artificial propagation to mitigate for FCRPS operations is discussed in Appendix F. The Action Agencies have proposed to continue funding safety-net projects for a number of ESUs "…as long as they are determined by NOAA Fisheries to be effective in reducing the short-term risk of extinction." NOAA Fisheries has determined that the safety-net programs proposed for funding by the Action Agencies continue to be effective as described.

6.1.3 Methods for Determining Net Effects of FCRPS and Non-hydro Actions

Some elements of the proposed action (e.g., FCRPS operations) would be more likely than the reference operation to result in reduced numbers, reproduction, or distribution of listed species or alter essential features of critical habitat, while other elements (e.g., off-site actions) would likely show better results. It is necessary to determine the net effects of these adverse and beneficial effects for each listed ESU. Professional judgment is required to determine the net effect, because it is not possible to evaluate the effects of all activities quantitatively or in identical units (e.g., quantitative survival estimates for the effects of hydro operations for some ESUs must be compared with qualitative changes in habitat condition for off-site actions). Not all actions will occur over identical time periods, so the timing of effects must also be considered.

6.1.3.1 Net Effects Methods for Jeopardy Analysis

6.1.3.1.1 Proportional Changes. For the jeopardy analysis, the underlying assumption in the net effects determination is that a relative (i.e., proportional) change in a factor relevant to VSP characteristics in one life stage can be offset by a comparable proportional change in another life stage.

This can be demonstrated quantitatively for survival rates, as shown in Tables 6.2a and 6.2b, since cumulative survival through successive life stages is multiplicative. NOAA Fisheries also assumes that it can be applied to qualitative assessments of the benefits of habitat modifications affecting different life stages.

Table 6.2a. Hypothetical example: comparing proportional changes in different life stages.

	Absolute Change in survival	Proportional or Relative Change	Comments
Survival gap due to FCRPS operation:	45% - 50% = -5%	$\frac{45\% - 50\%}{50\%}$ = - 10%	An absolute change of -5% in the FCRPS corresponds to a relative change of - 10%
Increased # of smolts entering FCRPS to "fill the gap"	3.33 - 3% = +0.33%	$\frac{3.33\text{-}3\%}{3.33\%}$ = +10%	A 0.33% change in absolute survival upstream of the FCRPS (from 3% to 3.33%) corresponds to a +10% relative change that could be used to offset the reduction in survival.

Table 6.2b. The multiplicative effect of salmonid survival through different life stages.

# eggs x	egg-smolt survival x	survival in FCRPS =	# smolts exiting FCRPS
5000	0.03	0.50	75
5000	0.03	0.45	67
5000	0.0333	0.45	75

Effects of most proposed FCRPS operations can be described as expected changes in juvenile and adult survival rates, and these expected changes can be expressed as relative (*i.e.,* proportional) changes in survival rates. To illustrate, if smolt survival under the reference operation is 50% and smolt survival under the proposed action is 45%, the absolute change is -5%, but the proportional change is -10% ([proposed - reference] ÷ reference). To mathematically balance the 10% proportional reduction in smolt survival through the FCRPS, off-site actions would have to result in the equivalent of a 10% proportional survival increase in another life stage. That is, the current survival rate in another life stage would have to increase by a multiplier of 1.10 to balance. If NOAA Fisheries could quantify the egg-to-smolt survival rate in relevant tributaries, and if the baseline survival rate were 3%, proposed off-site actions would have to increase the egg-to-smolt survival rate to at least 3.3% for the combination of both actions to result in no net effect (0.03 x 1.10 = 0.033).

Multiplying the number of eggs by the survival rates in the different life stages provides the number of surviving smolts. This is shown in Table 6.2b.

6.1.3.1.2 Timing of Effects. Timing of effects is also an important consideration. Mortality associated with certain proposed FCRPS operations begins immediately and continues for at least the life of this Opinion. If mortality in all other life stages stays constant, this would result in a cumulative reduction in spawner abundance over time. For example, a 2% mortality rate would result in only 98% as many adults returning at the end of the first year; 96% (0.98*0.98) at the end of the second year; and 89% (0.98^6) at the end of six years. This cumulative reduction in abundance could be offset by an equivalent increase in survival of another life stage if that improvement also began in the first year. If the offsetting survival improvement was delayed, either because of a lag in implementation or in realizing benefits to fish (e.g., long-term habitat restoration projects), the needed survival improvement would have to be greater than the annual FCRPS mortality to provide an equivalent offset. The longer the delay, the greater the survival improvement would have to be. Alternatively, additional short-term actions could be implemented to offset the ongoing hydro mortality.

6.1.3.1.3 Consistency of Qualitative Evaluations of Effects. As described in section 6.1.2 and in Appendix A, an attempt was made to standardize qualitative characterizations of effects (i.e., Very Low, Low, Medium, High, or Very High increases or reductions in one or more VSP characteristics) across activities. NOAA Fisheries addressed this concern by assembling the qualitative evaluators to compare the procedures and values that each applied and to adjust those factors between evaluators until consistency had been achieved.

6.1.3.1.4 Population-level Net Effects: Two-Step Approach. For tributary habitat and artificial propagation programs, NOAA Fisheries first evaluated the net effects of the mitigative action at the population level, the appropriate scale of impact for important components of the proposed action. NOAA Fisheries performed this evaluation by applying the following two-step process. The first step was a "coarse screen" that evaluated whether the qualitative category or rank (Very Low to Very High) describing the hydropower effect was offset by activities ranked at this level or higher. For example, a Medium hydropower gap could be mitigated by non-hydro projects that were ranked Medium (or higher) for offset potential, considering any of the four VSP attributes. This approach is transparent and can be applied consistently, but gives the impression of "knife edge" precision in delineating the bounds of each qualitative category (e.g., less than two versus 2 to 24%). In fact, there is a great deal of uncertainty in estimating non-hydro potential. Therefore, a second step was also applied. The capacity to mitigate a hydropower effect was further evaluated by looking more closely at the placement of the benefits of a specific project within the qualitative range. For example, a 3% hydro effect (ranked as Medium: 2 – 24%) might be adequately offset by two habitat actions ranked as having Low (greater than 0 to less than 2%) non-hydro potential. Alternatively, a beneficial action at the Low end of the Medium category might be judged incorrectly to offset a hydro action producing an effect closer to the top of the Medium range, even though it passed the coarse screen. This approach considers the unique attributes of any non-hydro project and acknowledges that the qualitative characterization of habitat improvement activities, expressed as a change in survival rate, is unlikely to be accurate to within a few percentage points. This second step requires a more detailed explanation for NOAA Fisheries' determination that the effects of certain activities are at one end of the qualitative category or another.

The result of the population-level net effects analysis, after considering the potential of all non-hydro actions to offset proposed FCRPS operations and considering the relative timing of effects, was a determination that there is likely to be a "net improvement," "no change," or a "net reduction" in the VSP characteristics of each population. If the action was determined likely to cause a net reduction, the relative magnitude of the reduction was indicated, for use in both the jeopardy and adverse modification analyses.

6.1.3.1.5 Net Effects for Populations, Major Population Groups, and ESUs. In the 2000 FCRPS Biological Opinion, NOAA Fisheries' analysis for most ESUs assumed that every component population needed to achieve a certain level of improvement to meet or exceed the defined survival and recovery metrics. These needed levels of improvement were set as performance standards. Since then, the Interior and Willamette/Lower Columbia TRTs have drafted descriptions of the population structure of each Columbia basin ESU. Populations in close geographic proximity and with similar genetic characteristics were termed "major population groups" by the Interior TRT (the W/LC TRT used the term "strata," which for the purposes of this analysis, is the same concept). The major population groups for each ESU are identified in Section 4.0.

NOAA Fisheries determined if, on balance, each major population group experienced no change or an increase or decrease in VSP criteria, although the net effects for specific populations within a given major population group could be a mixture of "net improvement," "no change," or a "net reduction" in status of the VSP characteristics. Where such a mixture was difficult to interpret, NOAA Fisheries weighted the relative contribution of each population within each major population group by its relative abundance and productivity (currently and historically) and any unique traits of the population (e.g., the only summer-run population in a major population group) per Appendix A. If a population was historically small relative to other populations within the ESU and the population had no especially unique characteristics, it would have less weight in making a determination for the major population group than would a population that was a significant source of the ESU's abundance and/or had unique characteristics (e.g., the only summer-run population).

Once a determination was reached for each major population group, NOAA Fisheries determined whether the ESU as a whole experienced no change or an increase or decrease in VSP criteria. If the net effect of the proposed action was to reduce the VSP characteristics of any major population group, then NOAA Fisheries determined that the abundance, productivity, or distribution of the ESU was reduced by the proposed action. The magnitude of any such reduction was noted. In Section 8.0, NOAA Fisheries determined if this represented an "appreciable reduction" in the likelihood of both survival and recovery of the ESU in the wild. The specific major population group(s) affected within an ESU was relevant to this determination.

Only one major population group exists for four ESUs: UCR spring chinook, UCR steelhead, SR sockeye, and SR fall chinook. The two UCR ESUs have only three or four populations each, and, with so few, a reduction in numbers, reproduction, or distribution of any one population is likely to represent a reduction for the major population group as a whole. Because there is only one major population group, the same effect is experienced by the ESU. The case is even more dramatic with SR sockeye and SR fall chinook, ESUs for which there is only one population, so the population, the major population group, and the ESU are equivalent.

6.1.3.2 Net Effects Methods for Critical Habitat Determination

As described in sections 6.1.1 and 6.1.2, NOAA Fisheries evaluates the effects of hydro actions and non-hydro actions on component areas of designated critical habitat and, in particular, on the essential features of that critical habitat. To determine net effects, positive and negative actions affecting the same component areas and essential features were compared to determine if, on balance, there was no change, an alteration, or an enhancement of critical habitat function. For the first alternative analysis, in most cases, this analysis relied upon habitat information that was also considered in the jeopardy analysis. For the second alternative analysis, the habitat conditions resulting from the proposed action were compared with the condition of critical habitat existing at the time of listing of the particular ESU. If there was a net alteration of habitat function under either alternative method, NOAA Fisheries determined in Section 8.0 whether that constituted a destruction or adverse modification of critical habitat.

6.2 RESULTS COMMON TO MULTIPLE ESUS

6.2.1 Effect of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

The main differences between the proposed hydro operation and the reference operation are seasonal differences in flow through the Snake and lower Columbia rivers, differences in spill at FCRPS mainstem dams, and a change in the John Day reservoir elevation.

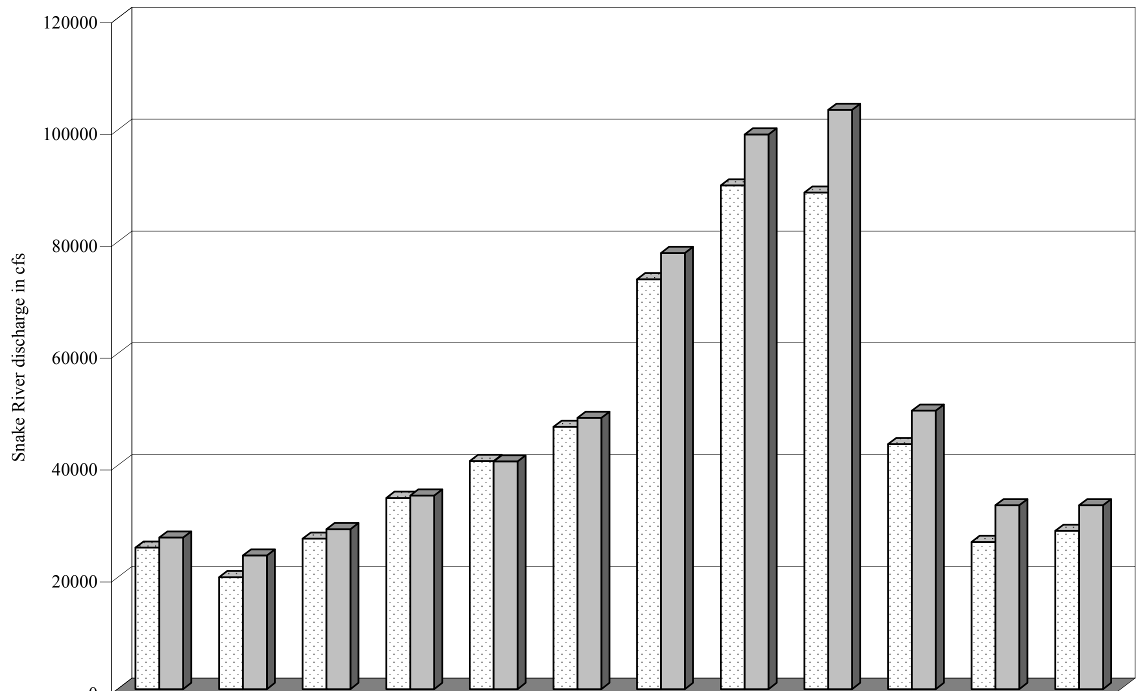
6.2.1.1 Flow and Water Quality

Flow influences water velocity and water quantity, the amount of spawning habitat and shallow-water rearing habitat below Bonneville Dam for some ESUs, as well as the size and physical characteristics of the near-ocean plume at the mouth of the Columbia River. Because the proposed action includes operations designed to provide flood control, irrigation, and other purposes not included in the reference operation, total and seasonal-average flow conditions vary between the two operating scenarios. Modeled flows under the two operating scenarios at specified locations are depicted in Figures 6.1 through 6.3. There is essentially no net difference in seasonal average spring flows in the Snake River between the proposed action and reference operation, when SR sockeye salmon, SR spring/summer chinook salmon, and SR steelhead are migrating through the action area (Table 6.3). Compared to the reference operation, the proposed hydro operation has slightly reduced lower Columbia River flows (-1.5%) during the spring, when SR sockeye salmon; SR spring/summer chinook salmon; SR,UCR, MCR, LCR, and UWR steelhead; UCR spring chinook; some populations of LCR chinook; CR chum salmon; and UWR chinook are migrating through the action area (Table 6.3). CR chum salmon may also be rearing in the action area during the early part of this period. Because the difference in spring flow is minimal, the proposed action is not likely to have more than a minimal effect on the functioning of either the migration corridor or juvenile rearing habitat during the spring.

Compared to the reference operation, flows resulting from the proposed hydro operation are 20% lower during the summer, when SR fall chinook, CR chum salmon (chum salmon migrate out in April peak, as per http://www.nwfsc.noaa.gov/publications/techmemos/tm32/Tables/table9.htm), and some populations of LCR chinook are migrating through and rearing in the action area. There is uncertainty in estimates of the associated difference in shallow-water rearing habitat below Bonneville Dam (including the estuary), but the 20% difference in flow is likely to reduce the availability of shallow-water rearing habitat during the summer. NOAA Fisheries considered two preliminary evaluations of the impacts of flow differences between the reference operation and proposed action on rearing habitat in the estuary. This evaluation focused on a three-month period in the summer (July- September) when differences between discharges at Bonneville Dam under the reference and UPA would be greatest. Differences in the discharge regimes could result in differences in water depth in the upper and lower estuary depending upon the bathymetry and topography in each area. Differences in water depth could affect the quantity and distribution of shallow water habitats, which are used by small juvenile salmon as rearing areas. Rearing areas provide essential features such as cover, shelter, water quantity and space. The lower summer flows below Bonneville under the UPA compared to the reference operation could alter the amount or distribution of juvenile salmonid rearing areas. Rearing habitat was defined by specific, physical metrics: shallow water habitat (SWH) between 0.1 and 2.0 meters depth (Bottom *et al.* 2001, USACE 2001).

Table 6.3. Simulated average seasonal flows (and flow ranges) in thousand cubic feet per second (kcfs) for both the reference and proposed action operations during spring and summer migration periods relevant to migrating listed juvenile salmon and steelhead for the years 1994 through 2003.
Source: BPA "HYDSIM" model studies 03Biop2004, October 21, 2004 and 03FSH05D9, August 2004.

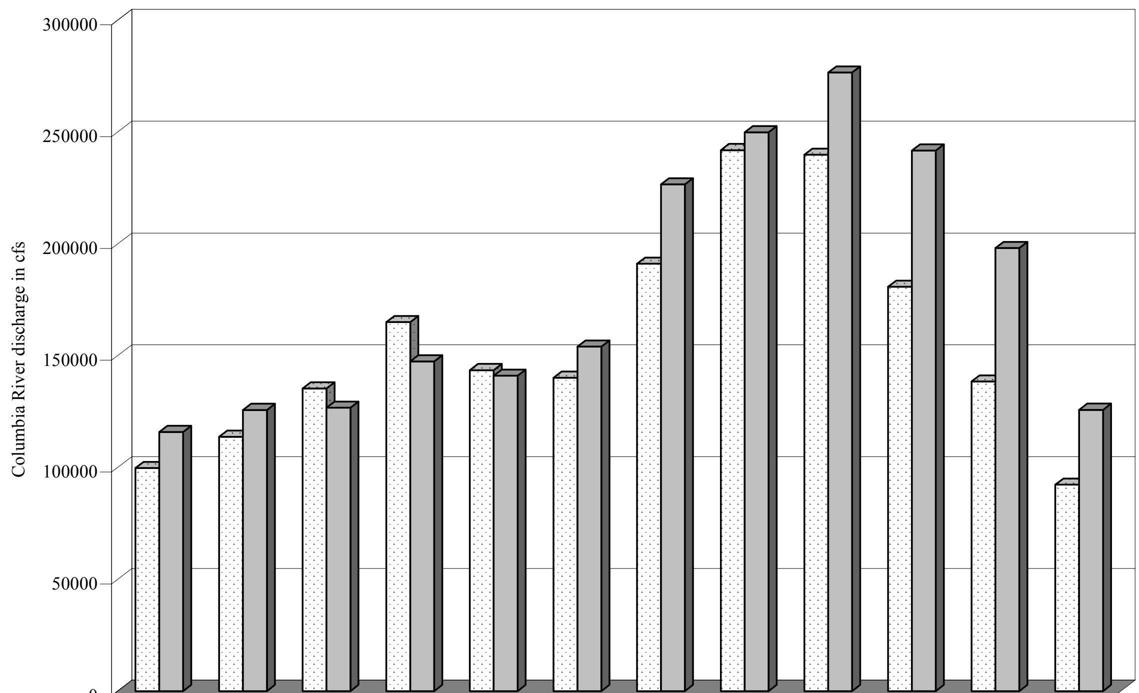
Reach - Season	Reference Operation	Proposed Action Operation	Absolute Difference (Proposed - Reference)	Percent Difference (Absolute Difference ÷ Reference)
Snake River – Spring (4/3 - 6/20)	93.0 (47.9 to 148.1)	93.0 (54.0 to 145.7)	none (+6.1 to -2.3)	0% (+12.8 to -1.6%)
Snake River - Summer (6/21 - 9/30)	45.0 (26.9 to 64.8)	42.1 (26.6 to 61.6)	-2.8 (-0.3 to -3.2)	-6.3% (-1.0 to -5.0%)
Lower Columbia - Spring (4/10 - 6/30)	256.9 (127.5 to 425.0)	255.1 (156.4 to 401.8)	-1.8 (28.9 to -23.2)	-0.7% (22.7 to -5.5%)
Lower Columbia - Summer (7/1 - 9/30)	189.5 (166.2 to 114.7)	151.5 (114.7 to 197.5)	-37.9 (-51.5 to -22.8)	-20.0% (-31.0 to -10.3%)
Lower Columbia -Fall and Winter (11/1 - 4/15)	162.6 (119.0 to 212.6)	173.5 (121.0 to 236.3)	+10.9 (+1.9 to +23.7)	+6.7% (+1.6 to +11.2%)



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Proposed Action	25300	20000	26900	34200	40800	46900	73300	90100	88800	43800	26300	28300
Reference Operation	27100	23900	28600	34600	40700	48500	78000	99200	103600	49800	32900	32900

Figure 6.1. Mean monthly Snake River discharge (cfs) at Lower Granite Dam under the proposed action and under the reference operation. Sources: Proposed Action, BPA HYDSIM Model run 03Biop2004, dated 10-21-04; Reference Operation, BPA HYDSIM Model run 03FSH05D91 dated 8-10-04.

At NOAA Fisheries' request, Hyde *et al.* (2004) evaluated the sensitivity of the amount and distribution of shallow-water habitat in the lower Columbia River (below RM 35) to changes in discharge at Bonneville Dam during the low-discharge period (July through September). This study focused on the sensitivity to changes in discharge in the range of 150-190 kcfs, which brackets the UPA and reference operations. Simulations of circulation patterns observed in the Columbia River during 1999-2002 constitute the basis for this analysis. In the lower 35 miles of the Columbia River, changes in operation of the hydropower system that result in discharges in the range of 150-190 kcfs appeared to have only slight impacts on the total area of shallow-water habitat available and the hours that shallow water habitat fit the specific depth criteria. Hyde *et al.* (2004) suggested that this was because the length of time an area was inundated increased with flow and as a function of interaction with the tide. The direction and strength of these impacts varied within the lower estuary.

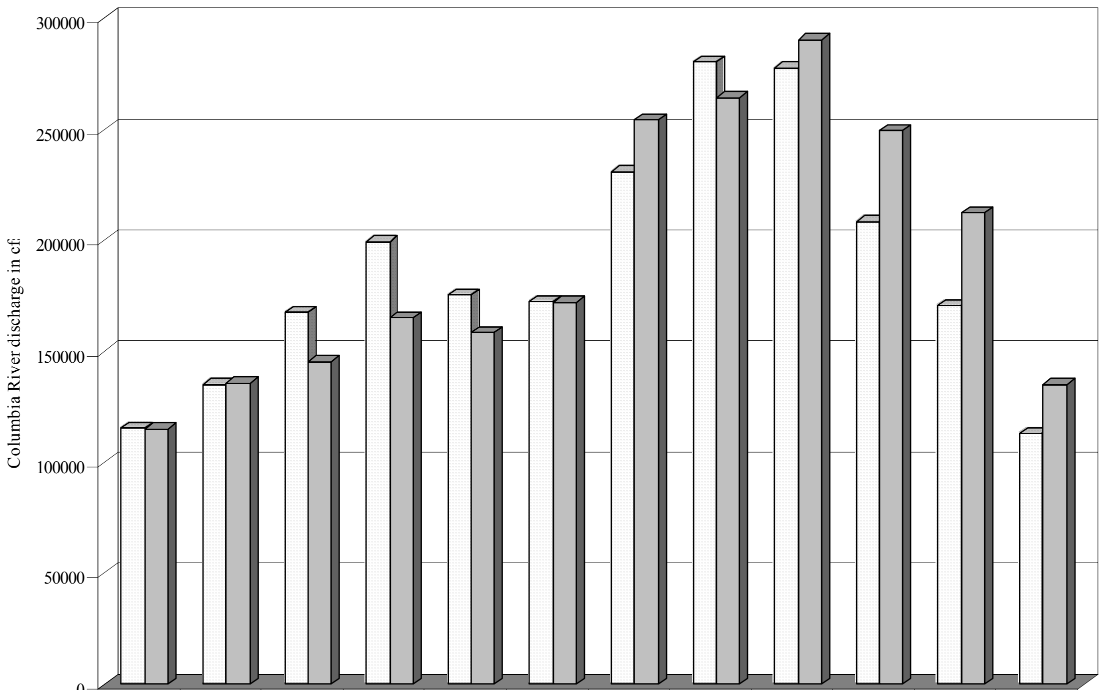


	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
□ Proposed Action	99700	113700	135300	165000	143500	140100	191100	241900	239800	180800	138500	92319
□ Reference Operation	115900	125700	126700	147400	141000	154000	226600	249900	276600	241700	198100	125787

Figure 6.2. Mean monthly Columbia River discharge (cfs) at McNary Dam under the proposed action, and under the reference operation. Sources: Proposed Action, BPA HYDSIM Model run 03Biop2004, dated 10-21-04; Reference Operation, BPA HYDSIM Model run 03FSH05D91 dated 8-10-04.

Jay *et al.* (2004) also completed a preliminary evaluation of impacts on fluvial and floodplain Shallow-Water Habitat Area (SWHA) of proposed changes in the Columbia River flow regime during July-September for the Skamokawa-Beaver Reach (RM35-RM55). SWHA responded only weakly over the range of flows in the UPA and reference operations. Maximum differences over the range of flows bracketed by the two operations are approximately 20,000 to 406,000 m^2 (5 to 100 acres) of shallow-water habitat for the present river morphology, which includes existing diked areas. Although the relationship between flow and SWHA is weak, confidence intervals suggest it is significant at the 95% level.

There is little information available for the remaining 92 river miles upstream of the Skamokawa-Beaver Reach to Bonneville Dam. Extrapolation of the SWHA area lost between the UPA and reference operations in the Skamokawa-Beaver Reach to this upstream reach results in approximately 700 fewer acres of shallow-water habitat during summer under the UPA. This is likely to be a conservative estimate, because the effect of flow may be increased as the river narrows and the extent of undiked shallow-water habitats associated with adjacent floodplains increase.



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
□ Proposed Action	115400	135000	167500	199400	175400	172400	231000	280500	277700	208500	170700	112900
▨ Reference Operation	115000	135700	145400	165200	158500	172200	254300	264400	290500	249500	212500	135000

Figure 6.3. Mean monthly Columbia River discharge (cfs) at Bonneville Dam under the proposed action, and under the reference operation. Sources: Proposed Action, BPA HYDSIM Model run 03Biop2004, dated 10-21-04; Reference Operation, BPA HYDSIM Model run 03FSH05D91 dated 8-10-04.

Fall and winter flows associated with the proposed hydro operation below Bonneville Dam are somewhat higher (+7%) compared to the reference operation, which would result in a greater quantity of spawning and incubating habitat for at least one population of CR chum salmon. It is unlikely that these somewhat higher flows would have a significant effect on mainstem spawning of SR fall chinook salmon, which generally takes place in relatively deep water downstream of some dam tailraces, but, to the extent that there is an effect, it would likely be beneficial.

Some water quality conditions associated with the proposed hydro operation could decline with a reduction in flows during summer months, compared to the reference operation. Higher temperatures during the summer months would most likely affect migrating juvenile SR fall chinook salmon and some populations of rearing CR chum salmon and LCR chinook salmon. Additionally, warmer summer temperatures may affect migrating adult SR and LCR fall chinook salmon and winter-run populations of several steelhead ESUs. It is unlikely that other water quality factors such as total dissolved gas levels would be higher for the proposed hydro operations relative to the reference operation, since voluntary spill for fish passage should not exceed total dissolved gas caps based on state water quality standards in either the reference or proposed operation, and involuntary spill is similar in the two operations.

6.2.1.1.1 Effects of 19 USBR Projects. The19 USBR projects located in the Columbia basin considered in this consultation (Table 1.1) contribute to flow depletions in the mainstem Columbia and Snake rivers. In addition to effects attributed to the reference operation , these projects cause about 2.28 Maf of total flow reductions annually as measured at Bonneville Dam, the vast majority of which is associated with the USBR's Columbia Basin Project (~2.16 Maf) (Appendix D, Attachment 1). The hydrologic effects calculated at the mouth of the tributary for each individual tributary consultation are assumed to be the hydrologic effects on the mainstem Columbia River for this consultation. This analysis is based on the assumption consistent with the UPA, Appendix B, that the mainstem flow effects due to irrigation diversions of the USBR's Yakima Project, Okanogan Project, Montana projects[2] and Dalton Gardens project in the Spokane area are non-discretionary and thus are not considered an effect of the UPA. Mainstem flow reductions for irrigation diversions would be the primary hydrologic effect of the continued operation of the USBR tributary projects as proposed (Appendix D, Attachment 1).

Under an alternative assumption that the effects of irrigation diversions in the Yakima, and similar projects mentioned above, should instead be attributed to the UPA, there would be an additional reduction in flows in the lower Columbia River and estuary from approximately mid-April through mid-October associated with water stored and/or diverted by these projects for irrigation. The largest such additional reduction would be attributed to the Yakima Project, which diverts approximately 2 Maf. The actual amount of the flow reduction would depend upon irrigation water returns to the Yakima River and its timing over the irrigation season. All other similar projects divert much smaller volumes of water for irrigation. See the 1999 FCRPS Biological Assessment, Appendix A.

It is likely that most of the depletions would occur during the summer, and therefore, the primary species affected would be juvenile SR fall chinook migrating through the lower Columbia River. While the actual depletion associated with the 2 Maf diversion is unknown, if it is near 2 Maf, then the effect on flow could be significant (i.e., 11 kcfs higher flows if the water is released over 90 summer days in the reference operation). Although modeling analyses have not been conducted, it is likely that this difference in summer flow rate between the reference and proposed operation could result in lower in-river survival under the proposed operation. However, as described in Section 6.4, most SR fall chinook would be collected and transported in barges under the proposed action. Thus few juvenile fall chinook would be exposed to the change in flows in the lower Columbia River, and the conclusions reached in that section would be unchanged.

Return flows from agricultural lands served by USBR irrigation projects can result in elevated water temperatures and can also carry an array of agricultural chemicals, some of which have been found to adversely affect anadromous salmonids. Agricultural wastewater returns to the Columbia River via several routes: shallow groundwater flows; effluent from aquifers subject to agricultural wastewater infiltration; and surface flows (i.e. agricultural wasteways). A monitoring program is underway to identify the water quality characteristics of wasteway returns from lands served by USBR's projects and USBR proposes to continue that effort. Waters from selected sections of the Columbia Basin Projects irrigation wasteways have been sampled and analyzed

[2] The USBR Montana projects include the Bitterroot, Big Flat Unit of the Missoula Valley and Frenchtown projects. All are projects that are located in areas blocked from salmon above Chief Joseph Dam.

by the USBR in conjunction with the USGS. The purpose of these efforts is to characterize the quality of the irrigation wasteway waters returning to the mainstem Columbia River above Priest Rapids Dam. If it is determined that water quality has been degraded by USBR-related agricultural practices, then the biological effects will be evaluated and appropriate corrective actions undertaken to protect listed stocks.

Several compounds of concern were detected in the water samples. However, the biological effects of the findings have not been evaluated. The effects of these constituents on salmonids are not fully known. Potential effects may include mortality, growth defects, migration interference, behavioral abnormalities, physiological responses, immunosuppression, and reproductive failures.

In addition to the mainstem effects of the 19 USBR projects, the total project effects include additional effects for those projects located in tributaries that are occupied by listed salmonids. Those additional effects occur in the tributaries where those projects are located. A list of such projects is found in Appendix B, page B-3 and B-4, to the UPA. NOAA Fisheries and USBR are taking a tiered consultation approach to the total effects of this subset of its 19 projects covered by this Opinion. This is the same approach called for by the RPA of the 2000 FCRPS Biological Opinion. The current Opinion considers the effects of these projects as they are manifested in the mainstem and estuarine portions of the action area. This would include any extent to which the effects occurring in the tributaries are manifested in the mainstem and estuary. To consider the localized tributary effects, NOAA Fisheries and USBR are conducting additional consultation analyses that will tier from and supplement this Opinion. For example, NOAA Fisheries completed a supplemental biological opinion for the Umatilla Irrigation Project dated April 23, 2004, in which these tributary effects are analyzed. The UPA, Appendix B, includes the commitment to pursue more detailed analysis for each of the remaining USBR projects with localized tributary effects. Supplemental consultations, in addition to consultation completed for the Umatilla Project, have been completed, are now under way, or are scheduled to begin for each of the USBR projects with tributary effects.

6.2.1.2 John Day Reservoir Elevation

The proposed action will raise the elevation of the John Day pool by roughly 5 to 7 feet from minimum operating pool (MOP) to the minimum elevation required for irrigation withdrawals. Compared to the reference operation, this operation results in roughly a 15% increase in water particle travel time through the reservoir and an increase of approximately 3800 to 4500 acres in available shallow-water rearing habitat within the John Day Reservoir (Ruff and Ross 2004). Ocean-type SR fall chinook rear primarily in lower Snake River reservoirs, particularly Lower Granite pool, and these fish have migration rates similar to spring migrants through the lower Columbia River during the summer months. Connor *et al.* (2004) state it is unknown presently which mainstem reservoirs are used by reservoir-type SR fall chinook for rearing purposes, the extent of that use, or the passage timing of this life history. Thus, to the extent that this operation is expected to have an impact on the rearing habitat for SR fall juvenile chinook in this area, which has already been significantly modified from riverine conditions by the existence of John Day Dam and Reservoir, it is likely to be beneficial. Quantitative estimates of the degree to which the increased pool elevation increases juvenile migration time and survival of ESUs migrating through John Day Reservoir are incorporated into the in-river and system survival estimates for migrating juveniles of several ESUs. These survival estimates are presented in subsequent sections of this chapter.

6.2.1.3 Spill

Compared to the reference operation, the proposed hydro operation contains less spill at some FCRPS mainstem dams. The reduction in spill is particularly noteworthy during the spring migration period at Little Goose, McNary, and John Day dams, all of which currently operate to a 12-hour spill operation for fish passage in the proposed action, compared to 24-hour spill in the reference operation. Spill primarily affects the ability of juvenile migrants to safely pass dams, which function as partial barriers to migration and can also result in migration delays. Spill is generally acknowledged as the safest route of dam passage (Ferguson *et al.* 2004). The degree to which this affects safe passage is informed by quantitative survival estimates presented later in this section. However, increases in spill efficiency through the installation and use of forebay guidance devices or removable spillway weirs, as proposed in the intermediate and long-term hydro operations, would be expected to diminish the overall impacts of UPA spill relative to the reference operation.

6.2.1.4 Juvenile Fish Transportation Operations

The Action Agencies' proposed action for transportation calls for the following measures in the spring at lower Snake River collector dams of spring migrants.

In years when the seasonal average Snake River flow at Lower Granite is expected to be less than 70 kcfs, maximum collection and transportation will occur at the three Snake River collector dams from the date the juvenile bypass systems begin operation. Consistent with current practices, no transportation would be provided in the spring from McNary Dam on the Columbia River. Due to the mixed benefits of early season transport, however, collection for transport will not be initiated until April 20 in those years where average seasonal flows are expected to equal or exceed 70 kcfs. Prior to April 20, all collected fish will be bypassed back to the river. In those years where flows are anticipated to be between 70 and 85 kcfs, spill will be provided at the collector projects until April 20. Further investigations into spill patterns (e.g., large gate openings/bulk spill) that provide optimum spillway survival conditions in these lower flow conditions will be coordinated through the Corps' Fish Facility Design Review Work Group (FFDRWG) process. Neither the proposed action nor the reference operation called for transportation at McNary Dam in the spring.

The Action Agencies' proposed action transportation protocol at the three lower Snake River collector projects for spring juvenile migrants is as follows:

	< 70 kcfs	**70-85 kcfs**	**> 85 kcfs**
Transport	Maximize	Initiate Collection April 20	Initiate Collection April 20
Bypass	None	Bypass Through April 19	Bypass Through April 19
Spill	None	Spill Through April 20	Spill Through June 20

It was assumed that summer transport operations under both the proposed hydro operation and the reference operation would be the same as defined in the 2000 Biological Opinion, i.e., no spill at collector projects and all collected fish to be transported from Lower Granite, Little Goose, Lower Monumental, and McNary dams.

Thus, for both operations, the summer transportation protocol for juvenile SR fall chinook salmon calls for the following actions:

- All fish collected at three Snake River collector dams and McNary Dam will be transported.
- Spill will not be provided during the summer period at the Snake River collector dams and McNary in order to maximize the number of fish collected and transported.
- Spill will be provided at non-collector dams, including Ice Harbor, John Day, The Dalles and Bonneville, on a 24-hour basis from approximately June 21 through August 31 for fish passage, but at different levels at some dams (Tables D.5 and D.6).

For the summer transport operations in the reference operation, NOAA Fisheries determined to continue the same transport operation as called for in the 2000 Biological Opinion. This is based on Williams *et al.* (2004), which states that "no empirical evidence exists to suggest that transportation either harms or helps fall chinook salmon." Thus, it is uncertain whether transport provides a benefit or a detriment for SR fall chinook.

Given the uncertainty surrounding the effects of transportation for summer migrants, NOAA Fisheries exercised its best professional judgment in order to include transportation in the reference operation. A significant consideration is that, for the past several years since the 2000 Biological Opinion, the region has experienced above-average adult returns of SR fall chinook under a strategy that maximizes transportation of juvenile SR fall chinook during the summer months. Without better information, a change to a strategy of leaving more fish in the river could either further improve or instead reduce the level of adult returns. The risk of a reduction in adult returns associated with leaving more fish in the river is less acceptable than the risk of failing to achieve even higher adult returns than the record numbers observed during the past four years.

Therefore, for the reference operation, NOAA Fisheries' transport strategy will be to use the same approach identified in the 2000 Biological Opinion, i.e., to maximize juvenile fish collection and transportation due to concerns about low in-river survival rates. However, given the absence of empirical information on the benefits of transportation for this stock, the Action Agencies' proposal to initiate an in-river survival and summer transport evaluation in the Snake River by 2007/2008 is an important component of this strategy.

Higher summer flows provided under the reference operation are intended to help move juvenile fish to the Snake River collector projects in a timely manner, as well as to improve in-river survival rates for those fish not transported (Williams *et al.* 2004). Even with the higher flows provided in the reference operation, average summer flows are often below the biological flow objectives (the Snake River flow objective is only met 10% of the time in the reference operation), and water temperatures can exceed the 20° C State of Washington water temperature standard in portions of the lower Snake River. Thus, under this transport strategy, fish spill continues to be curtailed at the four transport projects, and all collected fish are transported during the summer to try to improve overall juvenile fish survival. For those relatively few fish that remain in-river to migrate on their own, higher flows and 24-hour spill at each non-collector dam are provided in the reference operation to maximize in-river survival to below Bonneville Dam.

The spring Snake River transportation operations specified in the final proposed action differs from the reference operation in several minor ways. An understanding that both operations considered three tiers of flow thresholds helps clarify the differences between the proposed action and reference operations. The three flow conditions considered when spring seasonal average flows at Lower Granite Dam were: 1) less than 70 kcfs, which represent approximately the lowest 15% of flow years, 2) between 70 kcfs and 85 kcfs, which represent approximately the lower 15 – 25% of flow years, and, 3) greater than 85 kcfs.

Reference operation transportation protocol at lower Snake River collector projects for spring juvenile migrants is as follows:

	< 70 kcfs	**70-85 kcfs**	**> 85 kcfs**
Transport	Maximize	Initiate Collection April 1	Initiate Collection April 1
Bypass	None	None	None
Spill	None	Spill Through May 1	Spill Through June 20

There is no difference between the reference and proposed action transport operations when spring seasonal flows are projected to average less than 70 kcfs. During these low-flow years, both operations call for maximizing fish collection and transportation. This is accomplished by providing no spill, and transporting all fish collected as soon as the collection facilities are made operational in the spring. This typically occurs in late March to early April.

When average spring flows are projected to be between 70 and 85 kcfs in the Snake River, the proposed and reference operation differ in the manner in which collected fish are managed and the duration for which spill is provided. Both operations call for spill early in the season, but change to a maximum transport operation after a specified date. The proposed action calls for returning all fish collected back to the river through April 19, and stopping spill at collector projects on April 20, thus adopting a maximum transportation operation beginning April 20. The reference operation called for transporting all fish collected beginning in March, and providing spill until May 1, after which spill stops, thus maximizing transportation beginning May 1.

When spring seasonal flows are projected to exceed 85 kcfs on a seasonal average basis, the proposed action and reference operation differed only in how collected fish were managed through April 19. The proposed action calls for returning all fish collected back to the river through April 19, and beginning to transport fish on April 20. The reference operation called for transporting all fish collected from the date when the collection facilities became operational.

Both operations incorporated recent empirical information which indicates there is typically no consistent benefit provided from transportation through much of April (Williams *et al.* 2004, Anderson *et al*. 2004). Both operations also maximized transportation during low-flow years because of the poor survival observed for in-river juvenile migrants, particularly steelhead, during low-flow years. The April 20 transport date selected for the proposed action reflected concerns about in-river survival data for steelhead, which indicated that in 1999, the only wild steelhead to return in any numbers were those that were transported in April. Thus, the reference operation may understate the value of transport for some stocks at some times.

The Action Agencies also proposed improving transport operations by adding more barges. The theoretical value of increasing the number of barges results from lower holding densities during transport operations and the potential for added flexibility in the barging schedule, which would facilitate the release of fish in areas where they could be less prone to predation. Furthermore, new barges could theoretically improve the survival of barged fish and increase the value of “D” by several percentage points. Research is planned to evaluate any potential operational or survival benefits that new barges may provide.

6.2.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival

6.2.2.1 Effects of the Proposed Hydro Operation on Juvenile Salmon and Steelhead

NOAA Fisheries’ modeling results indicate that both the proposed near-term (2004) and intermediate-term (2010) hydro operation and system configurations are estimated to reduce in-river and system survival for several ESUs, compared to survival estimated to occur under the reference operation (Tables 6.5 and 6.7; Appendix D). For other ESUs, there is not a significant difference in survival between the proposed 2004 hydro operation and the reference operation. However, modeling results also indicate that the proposed long-term (2014) hydro operation, with expected survival improvements, is estimated to either reduce or close the survival gaps for all ESUs when compared to survival estimated under the reference operation (Tables 6.6 and 6.8; Appendix D). As described in Appendix D, the range of estimated survival results reflects variation in 8 recent years (for SR fall chinook) or 10 recent years of study (for spring chinook and steelhead ESUs). That variation is caused both by environmental variability (extreme low runoff in 1994 and 2001, compared with moderate to high runoff in other years) and the differential survival of fish under similar runoff conditions in different years, as determined by empirical survival estimates (Williams *et al.* 2004).

Additional effects of the proposed action on juveniles are described for individual ESUs in Sections 6.3 through 6.14.

6.2.2.2 Effects of the Proposed Hydro Operation on Adult Salmon and Steelhead

Adult salmon and steelhead must pass up to eight mainstem dams and reservoirs to reach their natal spawning streams and river reaches. Each FCRPS project within currently occupied habitats imposes stresses on migrating adults. Those project-induced effects most likely to adversely affect adult survival are: delay and delay-induced predation, water quality changes (e.g., total dissolved gas concentrations and water temperatures), and fallback and volitional downstream passage (e.g., kelts).

NOAA Fisheries has estimated the recent survival rates of adult anadromous fish passing through the FCRPS (Table 6.4).[3] System passage survival estimates shown in Table 6.4 include all unknown causes of adult mortality. Efforts have been made to exclude fish mortalities for reasons not associated with the FCRPS. Fish that turn off into tributaries or are captured in a fishery are not included in the estimate. However, fish injured or infected prior to entering the FCRPS are included. Also, the sampling technique itself, including anesthesia and the insertion of radio-telemetry gear into body cavities, may also cause mortalities that occur following passage of Bonneville Dam. Those mortalities would be incorrectly attributed to dam passage in Table 6.4, but given the high rate of adult survival, non-dam-caused mortality does not appear to be a significant component of the calculation. To determine the likely effect of the proposed action, we investigated those differences in conditions between the reference operation and the proposed hydro operation that might affect adult survival.

Table 6.4. Estimated minimum adult survival and unaccounted loss from 1996 - 1998 and 2000 - 2002 through the FCRPS (Bonneville Dam tailrace to Lower Granite or McNary dams). Source: Appendix D.

ESU	Mean Unaccounted Loss	Minimum Mean Survival	Number of Dams Passed	Per Project Survival
Chinook Salmon				
SR spring/summer chinook	0.154 (.064 - .250)	0.846 (.750 - .936)	8	0.979
SR fall chinook	0.153 (.077 - .200)	0.847 (.800 - .923)	8	0.980
UCR spring chinook	0.080 (.065 - .089)	0.920 (.911 - .935)	4	0.979
LCR spring chinook	0.035 (none)	0.965 (none)	1	0.965
LCR fall chinook	0.020 (none)	0.980 (none)	1	0.980
Steelhead				
SR steelhead	0.168 (.101 - .250)	0.833 (.750 - .899)	8	0.977
UCR steelhead	0.059 (.039 - .078)	0.941 (.922 - .961)	4	0.985
MCR steelhead	0.067 (none)	0.933 (none)	3	0.977
LCR steelhead	0.026 (none)	0.974 (none)	1	0.974
LCR coho	0.020 (none)	0.980 (none)	1	0.980
SR sockeye salmon	0.169 (none)	0.831 (none)	8	0.977

[3] A discussion of the data and methods used to make these estimates is provided in Appendix D, and key assumptions are summarized in Section 5.2.2.3.1.1.

6.2.2.2.1 Delay and Delay-induced Predation. To pass each dam, adult fish must successfully locate and ascend the project fish ladder(s). The ability to successfully pass each dam has been found to be affected by project configuration and various operating characteristics, principally attraction flow rates, project spill patterns, and powerhouse discharge patterns. However, Bjornn *et al.* (2000) estimated that the median time to transit the lower Snake River in 1993 was the same or less with dams than it would be without dams, suggesting that adult passage timing is relatively unaffected by the FCRPS. This is due to the faster transit times through project reservoirs than would occur in the natural river.

High rates of spill have been found to delay project passage. The spill rates that cause a notable increase in delay are those associated with involuntary spill, an unavoidable consequence of dam existence. It is unlikely that any of the configuration and operation changes considered in the reference operation would substantially reduce adult passage delay. The additional daytime spill considered under the reference operation could result in a slight increase in the delay of migrating adults. The effect of a small increase in delay on adult survival or spawning success is unknown. Changes in project configuration and operation under the proposed hydro operation would also be unlikely to change adult passage delay. Under the proposed action, any passage delay problems identified by ongoing monitoring and evaluation would be addressed through the Regional Forum.

Pinnipeds (seals and sea lions) protected under the Marine Mammal Protection Act of 1972 have been increasing in recent years in the vicinity of Bonneville Dam, feeding primarily on spring chinook salmon. The number of pinnipeds, primarily California sea lions (*Zalophus californianus*), observed each year from 2002-2004 has increased to 30, 106, and 101, respectively. The estimated percentage of the spring chinook run consumed has also increased each year to 0.3%, 1.1%, and 2.0%, respectively (Stansell 2004). NOAA Fisheries and the Action Agencies are concerned about the recent growth in pinniped predation near Bonneville Dam and the potential impact this source of mortality places on species recovery. Under the proposed action, pinniped predation would be monitored and managed as appropriate.

A reviewer of the September 9, 2004 draft of this Opinion noted that the Opinion should include provisions based on future re-authorization of the Marine Mammal Protection Act, which would allow harvest of pinnipeds by certain groups and therefore reduce pinniped predation on listed salmon. Such provisions may be considered through the reauthorization process of that Act. However, until then, nothing specific regarding this method of management can be considered. NOAA Fisheries does agree that management options are needed to help reduce the impact of pinnipeds in the tailrace of Bonneville Dam, but the presence of these animals at this location is probably due more to the presence of the dam than its operation.

6.2.2.2.2 Water Quality Effects on Adult Passage Survival. Migrating adult salmon require river flows of sufficient quality to reach spawning grounds and spawn successfully. Specific ranges of the water quality components (i.e., water temperature, turbidity, and total dissolved gas) are needed for successful migration. The preferred temperature range for migrating adult salmon is 7 to 14.5˚ C, with upper and lower lethal limits of 0 and 25˚ C (Bell 1991). High concentrations of dissolved solids can irritate or suffocate salmon. Total dissolved gas concentrations (TDG) higher than 125% of saturation concentration due to high spill levels can impair and reduce adult survival (Ferguson *et al.* 2004). Biological requirements are the same for all ESUs migrating in the mainstem Columbia and Snake rivers.

Water temperatures as high as 23˚ C have been noted in localized surface water areas in the FCRPS, but summer surface (depth ≤ 15 feet) water temperatures generally do not exceed 22˚ C (DART, U. Wash.). High water temperatures cause metabolic stress in adult salmon and increase the virulence of disease vectors. Higher spring and summer flow rates that would occur under the reference operation could reduce the maximum water temperatures in the system. The scale of that effect and the associated improvement in adult fish survival and spawning success is unknown. Under the proposed hydro operation, water temperatures would be very similar to those recently observed.

Turbidity extremes that can impair the survival of adult salmon generally do not occur in the mainstem Columbia and lower Snake rivers in the FCRPS.

Under the proposed hydro operation, voluntary spill for juvenile fish passage would continue to be managed to produce no more than 120% TDG below the dams. At this TDG level, no signs of gas bubble disease have been noted, and the adult anadromous fish survival effects are considered benign.

6.2.2.2.3 Fallback and Volitional Downstream Passage. Fallback refers to adult fish that pass a dam and then are entrained in the spillway, navigation lock, or powerhouse intakes and pass back through the dam. Fallback of adult spring/summer chinook passing dams during spill has been found to reduce the number of fish that passed between tops of ladders at Bonneville Dam and Lower Granite or Priest Rapids dams (after adjustments for harvest). Fallback (at Bonneville and Ice Harbor dams) of steelhead similarly has been found to reduce escapement (Keefer and Peery 2004). During 1996-2002, escapement, on average, was lower for fallback fish by 6.5% for spring/summer chinook ($P<0.05$), 19.5% for fall chinook ($P<0.005$), and 13.2% for steelhead ($P<0.005$) (Keefer *et al.* 2004). Multiplying the percent of reduction in escapement for fish that fall back times the percent of fish that actually fallback provides an estimate of the reduction in overall system escapement (e.g., steelhead: 13.2% lower escapement for fallback fish * 21.4% fish that fell back = 2.82% reduction in escapement). Accordingly, reductions in overall run escapements were estimated at 1.30% (range=0.46-2.27%), 2.26% (range=1.32-2.91%) and 2.84% (range=1.34-4.02%) for spring/summer chinook, fall chinook, and steelhead, respectively.

However, system-wide adult passage information showed no significant difference in spring/summer chinook and steelhead escapement due to fallback during spill (approximately 30-50 kcfs) and no spill periods in 2001 (Keefer and Peery 2004). Escapements of adult steelhead from Bonneville to Lower Granite Dam adjusted for harvest in 2000, 2001, and 2002 were very similar (87.6, 85.2 and 85.6%), even though 2001 had very little spill at dams compared with 2000 and 2002. No differences ($P<0.05$) in escapement were found for fallback of spring/summer and fall chinook with and without spill for all years (1996-2002) pooled (Keefer *et al.* 2004). These similar escapements with and without spill may be due to so few fish falling back during non-spill periods. One reviewer of the September 9, 2004 draft of this Opinion indicated that fallback of adult fish during no-spill periods would result in low survival. Based on Keefer and Peery (2004), as stated above, no differences in escapement were detected in comparisons of 2001 spill and no-spill periods for spring/summer chinook and steelhead, or for all years combined for spring/summer and fall chinook. Further, with all years combined, steelhead escapement was significantly higher (P=0.002) during no spill at John Day Dam and marginally higher (P=0.056) during no spill at Bonneville Dam.

Because more fish fall back during spill but fish escapement is similar for spill and no-spill conditions, it appears total adult survival in the hydrosystem is similar for spill and no spill conditions. Thus, the addition of daytime spill at three dams under the reference operation could result in more fish falling back, but overall adult survival is not expected to decrease. Because the proposed hydro operation would result in voluntary spill conditions very similar to current operations, no change in fallback rates is anticipated.

6.2.2.2.4 Kelts. Only recently have studies been conducted to identify kelt (post-spawning, downstream-migrating adult steelhead) numbers and to investigate downstream passage success and route-specific passage at dams. Effects of the proposed action are likely to be similar to effects observed in recent years. Studies conducted since 2000 have shown that over 13,000 kelts passed John Day Dam, and 83% of the kelts observed at Lower Granite Dam were females. For fish tagged and released at Lower Granite Dam, 3.8%, 13.3%, and 34.4% were detected below Bonneville Dam in 2001, 2002, and 2003, respectively (Boggs and Peery 2004). Migration rates in 2003 were positively correlated with river flow ($P<0.0001$, $R^2 = 0.63$). Conditions that provided the 34% survival to below Bonneville Dam include spill at dams in accordance with the 2000 Biological Opinion and a very large freshet in late May/early June when kelts were migrating.

Whether or not this impact differs from kelt survival that would be expected under the reference operation is unknown. Since kelts chose spill and sluiceway routes to pass dams and are known to migrate faster with higher flows (Boggs and Peery 2004), it is possible that the reduced spill at three lower Columbia River projects, compared to spill under the reference operation, could affect the survival of kelts that survive to those projects. If there were a difference in survival, it would only affect kelts during the initial phase of the proposed action. Installation of removable spillway weirs or surface bypass as a result of the UPA is anticipated to benefit kelt passage and survival due to the surface orientation of kelts.

Information regarding repeat spawning rates suggests that little or no difference in survival of kelts to returning adults would be expected from alternative dam operations. Repeat spawning rates for Snake River basin steelhead currently, with eight dams in place, average less than 2% (Ferguson *et al.* 2004). However, this is approximately the same repeat spawning rate as that observed when only two dams were in place (Whitt 1954), suggesting that factors other than dam passage have a more significant effect on kelt survival.

6.2.2.2.5 Summary of Adult Effects. NOAA Fisheries does not anticipate any difference in adult salmon, steelhead, or kelt survival rates between the reference operation and the proposed hydro operation. High per-project and system survivals indicate biological requirements of upstream-migrating adult salmon and steelhead generally are being and would continue to be met under the proposed action. Information is not available to determine whether biological requirements of kelts are being or would be met under the proposed action. Several of those commenting on the draft of this Opinion have indicated that adult passage success through the FCRPS has not been fully evaluated because spawning success after passage through the FCRPS has not been included. NOAA Fisheries concurs. Adult passage studies are being conducted and are proposed to continue under the UPA in order to estimate spawning success after passage through the FCRPS. Adult passage success through the FCRPS will be further evaluated, based on the results of these studies.

6.2.2.3 Mainstem Passage Improvements for Juveniles and Adults as a Result of 2000 Biological Opinion Implementation during 2001-2004

Included in the effects of the proposed action are effects of implementing hydro actions since adoption of the 2000 FCRPS Biological Opinion, which are reviewed below. More detailed Action Agency progress in implementing the Reasonable and Prudent Alternative (RPA) of the 2000 FCRPS Biological Opinion has been summarized in the 2001, 2002, and 2003 annual progress reports, as well as within the Action Agencies' 2003 Check-in Report. Progress in achieving the performance goals of the 2000 Biological Opinion has already been achieved. Key achievements since 2000 that are accruing increased juvenile and adult fish survival benefits in the hydro system over time are summarized below.

- Adult passage survival goals exceeded - Adult Snake River spring/summer chinook, Snake River fall chinook, and Snake River steelhead have survived passage through the FCRPS in 2001-2003 at rates exceeding the 2000 Biological Opinion passage goals. Exceeding the adult survival standard will yield increased juvenile production and thereby contribute to increased juvenile survival in subsequent years. Other than the maintenance of adult passage facilities, no further adult passage improvements appear to be needed to meet the 2000 Opinion's adult performance standards. However, those commenting on the September 9, 2004 draft of this Opinion have indicated that adult passage success through the FCRPS has not been fully evaluated because spawning success after passage through the FCRPS has not been included. NOAA Fisheries concurs. Adult passage studies are being conducted to estimate spawning success after passage through the FCRPS. Adult passage success through the FCRPS will be further evaluated, based on the results of these studies.

- VarQ flood control operation and Libby December 31 variable draft operations implemented – VarQ flood control operations at Libby and Hungry Horse reservoirs have been implemented on an interim basis since 2002 (Hungry Horse) and 2003 (Libby). The variable December 31 draft curves at the Libby project have also been utilized, beginning in 2004. These operations should increase the probability of achieving refill at Libby and Hungry Horse reservoirs and thereby improve the ability to meet the spring and summer flow objectives for listed salmon and steelhead.

- Transmission system constraints to Biological Opinion spill remedied – BPA has begun construction on the transmission lines called for in the 2000 Biological Opinion. Transmission system-caused constraints on voluntary fish spill levels will cease to be an obstacle in the 2004/2005 timeframe.

- The 2000 Biological Opinion spring and summer spill programs were implemented – The action agencies have implemented the Biological Opinion spill passage provisions each year with the exception of 2001 when a regional power emergency (permitted under the 2000 Biological Opinion) was declared.

- Dworkshak Reservoir has been drafted to provide summer cooling water in the Lower Snake – Biological Opinion recommendations for summer drafting at Dworshak have been followed each year since 2000. Heating and filter enhancements at the Dworshak National Fish Hatchery were completed in 2003, which enables continued cool water drafting from Dworshak without adverse effects on hatchery production.

- Substantial progress has been made on the development of surface passage technologies since 2000 - A Removable Spillway Weir (RSW) was built and tested at Lower Granite in 2002-2003. The Lower Granite RSW has been demonstrated to enhance in-river fish survival at reduced operational costs. An RSW will be built at Ice Harbor Dam for use in 2005. Plans for more RSWs at the remaining Snake River dams and McNary Dam are also being developed. In addition, a corner collector was installed at Bonneville Dam Second Powerhouse in 2003. Survival tests were conducted in 2004 and more tests are planned in 2005. Depending on the outcome of these tests, the corner collector technology may be applied at other Columbia River dams. A spill wall and bulk spill program was developed and tested at The Dalles Dam, and initial survival tests were encouraging. These efforts have positioned the Action Agencies well to respond to the growing regional interest in increased reliance on RSW/surface passage technologies.

- Chum spawning and rearing flows have been provided (below Bonneville Dam) – Chum spawning operations have been provided each year since 2001 and adult spawning numbers have increased dramatically each year since 2001.

- Project passage research has been heavily funded since 2000 - Action Agency research on juvenile passage survival through the hydro system has been heavily funded. Research funding in 2003 and 2004 has exceeded $30 million. Improved spill operations were developed at Ice Harbor and Lower Monumental dams. At The Dalles Dam, research studies led to the development of the bulk spill/spill wall approach on the northern edge of the spillway. Studies at Bonneville Dam have led to giving generating priority to the Bonneville 2nd Powerhouse, which has also reduced adult fallback at the project. Research at John Day and McNary dams is also expected to reveal methods to improve juvenile passage survival at those projects.

- Operation and maintenance funding has increased substantially since 2000 – O&M annual funding for fish passage facilities has increased from $31.5 million in 2000 to $40.1 million in 2003. Examples of O&M projects that enhance juvenile passage survival are the stilling basin repair at Lower Monumental Dam, the stilling basin repair at The Dalles, and repairs to spill gate hoists at McNary Dam.

- Predator control programs have been implemented since 2000 – The Northern Pikeminnow control program has been implemented each year since 2000. This program was expanded in 2002 and 2004. Annual reductions in pikeminnow populations have already substantially reduced smolt predation and will further reduce losses in future years. Tern predation has been reduced since the 2000 Biological Opinion. The tern colony at Rice Island was relocated, and an EIS that evaluates long-term management options is being developed.

6.2.3 Performance Standards, Annual Reports, and Comprehensive Evaluations

The 2000 Biological Opinion's RPA included annual reports of progress toward achieving performance standards, annual plans for implementation during subsequent one- and five-year periods, and "mid-point evaluations" in 2003, 2005, and 2008 to ensure that required measures were implemented and effective. The Action Agencies have modified these processes to reflect NOAA Fisheries' new assessment of the effects of the proposed action, the new proposed implementation schedule, duration of this Opinion, and the updated activities in the Updated Proposed Action (UPA).

6.2.3.1 Implementation Plans

The Action Agencies propose to continue preparing implementation plans to document the specific strategies, priorities, actions, measurable targets, and timetables that they intend to meet. NOAA Fisheries agrees that implementation plans are a useful tool for planning, adaptive management, and accountability under this Opinion. NOAA Fisheries will review Implementation Plans each year. As a matter of course, NOAA Fisheries will not issue formal annual Findings Reports, which are more appropriate when the Action Agencies are implementing an RPA recommended by NOAA Fisheries rather than their own UPA. However, NOAA Fisheries will conduct a review and inform the Action Agencies if an Implementation Plan appears inconsistent with the UPA that was evaluated in this Opinion.

The Action Agencies propose to employ an adaptive management framework for adjusting the proposed action to respond to new information. To guide this process, especially during development of the annual Water Management Plan, the Action Agencies propose that any adjustments to the proposed action described in this Opinion will be in accordance with a hydro operations performance standard for juvenile survival.

6.2.3.1.1 Hydro Operations Juvenile Performance Standard for Yearly Operations. The hydro operations performance standard for juvenile survival is to equal or exceed, in any given year, the level of juvenile survival that would otherwise occur if the specific hydro operations and system configuration improvements described in the Action Agencies' UPA were carried out as described. Estimates of these effects (means and ranges of in-river and system survival) are displayed in Tables 6.5, 6.6, and 6.7. Because the juvenile survival rate varies annually, the performance standard, as displayed in Tables 6.5 through 6.7 reflect a range of anticipated survival rates. This performance standard could be satisfied by alternative hydro operations and system configuration changes from those proposed in the UPA, or a combination of alternative hydro operations, system configuration improvements, and qualifying non-hydro actions.

Some reviewers of the September 9, 2004 draft of this Opinion stated that the Opinion should not allow for modifications of river operations on an annual basis using "offset actions" and that the relative merits of the offset actions should not be derived using the SIMPAS model. The estimated survival benefits of non-hydro actions will not be evaluated using the SIMPAS model.

Other reviewers support provisions allowing for alternative, more efficient hydro operations, but only if a net positive survival benefit accrues to listed species. For the purpose of meeting this performance standard, the Action Agencies can only receive credit for (1) non-hydro actions that are in addition to the non-hydro actions described in the UPA or in the Incidental Take Statement (Section 10.0), or (2) non-hydro actions described in the UPA or the Incidental Take Statement (Section 10.0) that result in estimated benefits in excess of those expected or relied upon in this Opinion, but only to the extent that such benefits exceed the benefits expected or relied upon.

In the case of an Action Agency proposal to implement a different operation than is described in the UPA, compliance with the hydro operations performance standard will be determined on a prospective basis using the SIMPAS model and flow-survival relationships as determined by NOAA Fisheries and as updated using the best available scientific information. The modeling will be based on expected runoff and passage conditions for the year or years in which the modified hydro operation would be implemented. One reviewer stated that, since it is difficult to accurately predict runoff and expected fish passage conditions in the Columbia or Snake rivers early in the year, any proposed operations that would reduce survival in the FCRPS could have a larger impact than estimated in the model. In the event that this pre-season modeling, which will utilize the most current NOAA Northwest River Forecast Center runoff forecasts, predicts that the alternative hydro operations, plus such non-hydro actions that qualify for crediting, will equal or exceed the level of juvenile survival that would otherwise occur if the hydro operation in the UPA were carried out, it would be expected that the hydro operations performance standard for juvenile survival would be satisfied by the alternative hydro operation and qualifying non-hydro actions. Actual empirical reach survival data will be used post-season to confirm whether or not the hydro performance standard was achieved. Plus, subsequent annual planning would consider previous years' empirical survival performance to ensure adequate progress is being made.[4]

6.2.3.2 Annual Progress Reports

The Action Agencies propose to continue preparing Progress Reports each year to document the activities implemented to date, estimates of juvenile and adult survival through the FCRPS, and progress towards meeting programmatic level performance targets and intermediate milestones for offsetting actions. The Action Agencies also propose to report on adult abundance and trends in adult abundance for listed ESUs in the action area. NOAA Fisheries agrees that these reports will be useful for confirming assumptions applied in the analyses included in this biological

[4] NOAA Fisheries and the Northwest Power and Conservation Council jointly sponsored a symposium in November 2004 to examine the state of the science regarding the relationship between flow and survival for juvenile summer migrants. NOAA Fisheries expects the outcome of this symposium to further inform the flow-survival relationships used in evaluating these alternative actions.

opinion (Section 6) and for tracking authorized incidental take associated with the proposed action (Section 10). This information will also be useful for NOAA Fisheries to evaluate whether new information reveals effects of the action that may affect listed species in a way that was not previously considered (Section 12).

The Action Agencies propose to include in the Annual Progress Reports post-season evaluations of juvenile in-river and system survival, based on empirical reach survival estimates. If the Annual Implementation Plan included pre-season estimates of the expected survival rates resulting from alternative hydro operations from those in the UPA, the post-season estimates will be compared with the pre-season estimates. This information will then be available to inform, and, if necessary, adjust accordingly, the next year's Annual Implementation Plan.

6.2.3.3 Comprehensive Evaluations in 2007 and 2010

The Action Agencies propose to produce comprehensive evaluations of programmatic progress in 2007 and again in 2010. These check-in reports will also serve as the annual progress report for the year in which they are provided. Each comprehensive evaluation will primarily focus on the following programmatic performance targets to determine whether cumulative implementation of actions remains consistent with the objectives of the UPA evaluated in this biological opinion. It is appropriate that these evaluations replace the 2005 and 2008 check-ins called for in the 2000 Biological Opinion's RPA in light of the review this biological opinion is providing, based on the best scientific information available in 2004.

6.2.3.3.1 Hydro Operations Juvenile Performance Standard. The Action Agencies propose a hydro operations performance standard for juvenile survival that equals or exceeds the levels of juvenile in-river and system survival displayed in Tables 6.5, 6.6, and 6.7, unless replaced by an equivalent combination of hydro operations and non-hydro offsets through the Annual Implementation Plans (see above). This is essentially the same juvenile survival standard that will be evaluated prospectively for development of the Annual Implementation Plan. However, for purposes of the comprehensive evaluations, it will be evaluated retrospectively as the mean and range of recent survival rate estimates.

6.2.3.3.2 Hydro Operations Adult Performance Standard. The Action Agencies propose a hydro operations performance standard for adult survival that equals or exceeds the level of adult survival in Table 1 of Attachment 4 of Appendix D of this biological opinion. These are the updated adult survival levels that have occurred in recent years, both before and after the 2000 biological opinion. Because the level of adult survival is subject to variation, the performance standard, as displayed in Table 1 of Attachment 4 of Appendix D, reflects a range of anticipated survival. It will be evaluated as the mean and range of survival rates estimated in the most recent 3-5 year period for the comprehensive evaluations.

6.2.3.3.3 Remaining Difference between Reference Hydro and Proposed Hydro Operations. In order to avoid the possibility that annual survival differences between the reference operation and the proposed hydro operation will constitute an appreciable reduction in the likelihood of an ESU's survival and recovery, the Action Agencies proposed to compensate for any differences with a combination of proposed non-hydro offsets. The general magnitude of the expected effects of the non-hydro offset program (VL, L, M, H) is defined for each element of the program in 2004 and 2010 in Table 6.8. For the 2007 comprehensive evaluation, intermediate values would be expected. To aid in this evaluation, the following information will be reviewed.

Northern Pikeminnow Reduction Program Performance Standard. The Action Agencies propose an average annual exploitation rate of 14-16% as a programmatic performance standard, as well as:

- annual effort is consistent with that assumed in the biological opinion

Avian Predation Reduction Performance Standard. The Action Agencies propose:

- annual effort is consistent with that assumed in the biological opinion

Estuary Performance Standard. The Action Agencies propose an estuary performance standard of:

- completing the specific estuary projects listed under "Estuary Actions" in the UPA, no later than 2010,

Tributary Performance Standard. The Action Agencies propose a tributary performance standard of:

- meeting the "cumulative metric goals" described for 2007 and 2010, which are listed for each relevant ESU in the UPA.

Hatchery Performance Standard. The Action Agencies propose a hatchery performance standard of:

- effects consistent with assumptions in the biological opinion.

Table 6.5. Estimated average juvenile and adult survival rates over 1994-2003 water years through the FCRPS under the 2004 proposed hydro operation and system configuration. These estimates do not include possible post-Bonneville latent mortality of in-river migrants (Section 6.2.2.1).

ESU	Estimated Juvenile In-river Survival Rate	Estimated Juvenile System Survival Rate (including transport latent effects)	Estimated Adult Survival Rate
SR Spring/Summer Chinook Salmon[3]	50.2% (38.3% to 57.7%)	51.5% (48.8% to 53.4%)	84.6% (75.0% to 93.6%)
SR Fall Chinook Salmon[,5]	14.2%(8.4% to 21.9%) 5.7 in-river fish per 1000 @ LGR pool alive below BON (2.9-10.7)	N/A	84.7% (80.0% to 92.3%)
UCR Spring Chinook Salmon	67.3% (55.1% to 74.9%)	N/A	92.0% (91.1% to 93.5%)
LCR Chinook:			
Gorge Fall MPGs[6]	86.0% (76.7% to 97.2%)	N/A	98.0% (no range avail.)
Gorge Spring MPGs[7]	90.0% (85.5% to 93.5%)	N/A	96.5% (no range avail.)
Below BON Dam MPGs	N/A	N/A	N/A
UWR Chinook Salmon	N/A	N/A	N/A
SR Steelhead[4]	30.5% (4.5% to 42.9%)	48.9% (41.4% to 53.4%)	83.3% (75.0% to 89.9%)
UCR Steelhead	46.8% (16.2% to 61.6%)	N/A	94.1% (92.2% to 96.1%)
MCR Steelhead:[8]			
Passing MCN-BON	46.8% (16.2% to 61.6%)	N/A	91.1% (no range avail.)
Passing JDA-BON	55.5% (26.1% to 72.5%)	N/A	93.3% (no range avail.)
From JDA Dam-BON	69.6% (39.6% to 88.0%)	N/A	93.3% (no range avail.)
Passing TDA-BON	72.4% (41.1% to 91.4%)	N/A	95.4% (no range avail.)
Passing BON Dam	83.8% (61.1% to 95.4%)	N/A	97.7% (no range avail.)
LCR Steelhead:[9]			
Passing BON Dam	83.8% (61.1% to 95.4%)	N/A	97.4% (no range avail.)
Below BON Dam	N/A	N/A	N/A
UWR Steelhead	N/A	N/A	N/A
CR Chum	N/A	N/A	N/A
SR Sockeye	N/A	N/A	83.1% (no range avail.)
LCR Coho[10]	N/A	N/A	98.0% (no range avail.)

[5] The estimated juvenile survival rates shown in this table for transported ESUs are only for those fish that remain in-river for their entire juvenile migration and are not transported.
[6] Estimated adult survival rates for LCR chinook salmon are based on per-project survival rate of SR fall chinook.
[7] Estimated adult survival rates for LCR (spring) chinook salmon are based on Bjornn *et al*. 2000.
[8] Estimated adult survival rates for MCR steelhead are based on per-project survival rate of SR steelhead.
[9] Estimated adult survival rates for LCR steelhead are based on Keefer *et al.* 2002.
[10] Estimated adult survival rates for LCR coho salmon are based on per-project survival rate of SR fall chinook salmon.

Table 6.6. Estimated average juvenile and adult survival rates over 1994-2003 water years through the FCRPS under the 2010 proposed hydro operation and system configuration. These estimates do not include possible post-Bonneville latent mortality of in-river migrants (Section 6.2.2.1).

ESU	Estimated Juvenile In-river Survival Rate	Estimated Juvenile System Survival Rate (including transport latent effects)	Estimated Adult Survival Rate
SR Spring/Summer Chinook Salmon[10]	54.1% (41.5% to 62.6%)	52.3% (50.0% to 54.6%)	84.6% (75.0% to 93.6%)
SR Fall Chinook Salmon[11, 12]	15.3% (9.0% to 23.6%)	N/A	84.7% (80.0% to 92.3%)
UCR Spring Chinook Salmon	71.9% (59.5% to 79.8%)	N/A	92.0% (91.1% to 93.5%)
LCR Chinook:			
Gorge Fall MPGs[13]	86.1% (76.8% to 97.3%)	N/A	98.0% (no range avail.)
Gorge Spring MPGs[14]	90.1% (85.6% to 93.5%)	N/A	96.5% (no range avail.)
Below BON Dam MPGs	N/A	N/A	N/A
UWR Chinook Salmon	N/A	N/A	N/A
SR Steelhead[10]	32.9% (4.9% to 46.2%)	49.5% (41.4% to 53.5%)	83.3% (73.0% to 89.9%)
UCR Steelhead	49.9% (17.5% to 65.5%)	N/A	94.1% (92.2% to 96.1%)
MCR Steelhead:[15]			
Passing MCN-BON	49.9% (17.5% to 65.5%)	N/A	91.1% (no range avail.)
Passing JDA-BON	57.4% (26.9% to 74.8%)	N/A	93.3% (no range avail.)
From JDA Dam-BON	72.0% (40.9% to 90.9%)	N/A	93.3% (no range avail.)
Passing TDA-BON	73.8% (41.9% to 93.1%)	N/A	95.4% (no range avail.)
Passing BON Dam	84.1% (61.2% to 95.7%)	N/A	97.7% (no range avail.)
LCR Steelhead:[16]			
Passing BON Dam	84.1% (61.2% to 95.7%)	N/A	97.4% (no range avail.)
Below BON Dam	N/A	N/A	N/A
UWR Steelhead	N/A	N/A	N/A
CR Chum	N/A	N/A	N/A
SR Sockeye	N/A	N/A	83.1% (no range avail.)
LCR Coho[17]	N/A	N/A	98.0% (no range avail.)

[11] The estimated juvenile survival rates shown in this table for transported ESUs are only for those fish that remain in-river for their entire juvenile migration and are not transported.
[12] The estimated juvenile survival rates shown in this table for transported ESUs are only for those fish that remain in-river for their entire juvenile migration and are not transported.
[13] Estimated adult survival rates for LCR (fall) chinook salmon are based on Bjornn *et al.* 2000.
[14] Estimated adult survival rates for LCR (spring) chinook salmon are based on per-project survival rate of SR spring/summer chinook salmon.
[15] Estimated adult survival rates for MCR steelhead are based on per-project survival rate of SR steelhead.
[16] Estimated adult survival rates for LCR steelhead are based on per-project survival rate of SR steelhead.
[17] Estimated adult survival rates for LCR coho salmon are based on per-project survival rate of SR fall chinook salmon.

Table 6.7 Estimated average juvenile and adult survival rates over 1994-2003 water years through the FCRPS under the 2014 proposed hydro operation and system configuration. These estimates do not include possible post-Bonneville latent mortality of in-river migrants (Section 6.2.2.1).

ESU	Estimated Juvenile In-river Survival Rate	Estimated Juvenile System Survival Rate (including latent effects)	Estimated Adult Survival Rate
SR Spring/Summer Chinook Salmon[10]	56.3% (42.6% to 65.4%)	53.1% (51.0% to 55.6%)	84.6% (75.0% to 93.6%
SR Fall Chinook Salmon[18, 19]	16.1% (9.5% to 24.9%)	N/A	84.7% (80.0% to 81.3%)
UCR Spring Chinook Salmon	73.5% (60.5% to 82.7%)	N/A	92.0% (91.1% to 93.5%)
LCR Chinook:			
Gorge Fall MPGs[20]	86.1% (76.8% to 97.3%)	N/A	98.0% (no range avail.)
Gorge Spring MPGs[21]	90.6% (85.7% to 94.3%)	N/A	96.5% (no range avail.)
Below BON Dam MPGs	N/A	N/A	N/A
UWR Chinook Salmon	N/A	N/A	N/A
SR Steelhead[10]	33.6% (5.0% to 47.2%)	49.5% (41.5% to 53.6%)	83.3% (75.0% to 89.9%)
UCR Steelhead	50.6% (17.6% to 66.4%)	N/A	94.1% (92.2% to 96.1%)
MCR Steelhead:[22]			
Passing MCN-BON	50.6% (17.6% to 66.4%)	N/A	91.1% (no range avail.)
Passing JDA-BON	58.2% (27.1% to 75.8%)	N/A	93.3% (no range avail.)
From JDA Dam-BON	72.9% (41.2% to 92.0%)	N/A	93.3% (no range avail.)
Passing TDA-BON	74.7% (42.1% to 94.2%)	N/A	95.4% (no range avail.)
Passing BON Dam	84.6% (61.3% to 96.3%)	N/A	97.7% (no range avail.)
LCR Steelhead:[23]			
Passing BON Dam	84.6% (61.3% to 96.3%)	N/A	97.7% (no range avail.)
Below BON Dam	N/A	N/A	N/A
UWR Steelhead	N/A	N/A	N/A
CR Chum	N/A	N/A	N/A
SR Sockeye	N/A	N/A	83.1 (no range available)
LCR Coho[24]	N/A	N/A	98.0 (no range available)

[18] The estimated juvenile survival rates shown in this table for transported ESUs are only for those fish that remain in-river for their entire juvenile migration and are not transported.
[19] The estimated juvenile survival rates shown in this table for transported ESUs are only for those fish that remain in-river for their entire juvenile migration and are not transported.
[20] Estimated adult survival rates for LCR (fall) chinook salmon are based on Bjornn *et al.* 2000.
[21] Estimated adult survival rates for LCR (spring) chinook salmon are based on per-project survival rate of SR spring/summer chinook salmon.
[22] Estimated adult survival rates for MCR steelhead are based on per-project survival rate of SR steelhead.
[23] Estimated adult survival rates for LCR steelhead are based on per-project survival rate of SR steelhead.
[24] Estimated adult survival rates for LCR coho salmon are based on per-project survival rate of SR fall chinook salmon.

Table 6.8. Summary of effects of proposed hydro operations and 2004 system configuration on listed ESUs. Relative (proportional) survival difference expressed as (Proposed - Reference) ÷ Reference.

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Spring/ Summer Chinook Salmon	-7.3% (-11.0 to -2.6%) Absolute Difference: -3.9% (-5.8 to -1.6%)	-1.9% (-4.7 to -0.2%) Absolute Difference: -1.0% (-2.5 to -0.1%)	None	-1.9% Absolute Difference: -1.0%	Minor or no differences in mainstem and below-BON estuary and plume habitat are expected, because the proposed action spring flows are very similar to the reference operation flows. Safe passage through barriers is significantly lower, based on the juvenile in-river survival estimate, most likely as a result of less spill. Little or no difference in water quality is expected.	Low

Table 6.8 (continued). Summary of effects of proposed hydro operations and 2004 system configuration on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Fall Chinook Salmon	-8.4%* (-10.9 to -5.4%) to -16.6%** (-24.6 to -7.1%) Absolute Difference: -1.3%* (-2.4 to -0.3%) to -2.8%** (-4.3 to -1.4%)	Under range of D-values:*** -1.9 to -3.2% relative system survival difference -3 to -4 difference in juveniles below Bonneville per 1000 juveniles arriving at LGR reservoir -5700 to -7200 difference in juveniles per two million arriving at LGR reservoir	None	Under range of D-values:*** -2.3 to -3% relative system survival difference -3 difference in juveniles below BON Dam per 1000 juveniles arriving at LGR reservoir*** -5800 to -6500 difference in juveniles below BON Dam per two million arriving at LGR reservoir***	Difference in mainstem and below-BON habitat is expected, because the proposed action summer flows are considerably less than the reference operation flows. Differences in spill affect safe passage through barriers. Possible difference in water quality (increased temperature) due to much lower flows in the proposed action.	Medium

* In-river survival sensitivity analysis in which pool survival between MCN and BON is assumed equal in both the reference and proposed operations. This sensitivity analysis was conducted in response to comments because of a lack of empirical reach survival data for SR fall chinook in the lower Columbia River. This difference applies only to the unknown, but small, proportion of the population that migrates entirely in-river.

** In-river survival analysis using SR fall chinook empirical reach survival data from the Snake River, extrapolated to the lower Columbia River using methods described in Appendix D. This difference applies only to the unknown, but small, proportion of the population that migrates entirely in-river.

*** The SR fall chinook in-river survival gap applies only to the unknown, but small, proportion of the population that migrates entirely in the river. Information regarding the proportion of transported fish and their survival rate is needed to properly weight the in-river results. As described in Section 5. 2.2.3.1.1, transport survival is unknown, because the post-Bonneville differential survival (D) is highly uncertain. However, a reasonable range of potential D-values (0.18 - 0.41) was calculated (Appendix D, Attachment 5; summarized in Section 5.2.2.3.1.1) for use in comparing relative differences between alternative operations.

Table 6.8 (continued). Summary of effects of proposed hydro operations and 2004 system configuration on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
UCR Spring Chinook Salmon	-5.8% (-8.5 to -2.6%) Absolute Difference: -4.1% (-5.1 to -2.0%)	N/A	None	-5.8% Absolute Difference: -4.1%	Same as SR spring/summer chinook, with less survival in proposed action due to higher lower Columbia River pool elevations.	Medium
UWR Chinook Salmon	N/A	N/A	N/A		Predominantly yearlings, but also some subyearling migrants. For yearlings, same mainstem habitat effects (minor) as for SR spring/summer chinook. For subyearlings, same as or possibly greater effects than for SR fall chinook for subyearlings. Reduced estuarine rearing habitat in summer for populations with small subyearling smolts.	Very Low

Table 6.8 (continued). Summary of effects of proposed hydro operations and 2004 system configuration on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
LCR Chinook Salmon	Yearling populations above BON: -1.6% (-1.9 to -0.6%) Absolute Difference: -1.4% (-1.8 to -0.6%)	N/A	0	Yearling populations above BON: -1.6% Absolute Difference: -1.4%	Same as SR spring/summer chinook (minor) for yearlings from populations that spawn above Bonneville (1 of 3 extant spring-run populations in 1 of 6 MPGs).	Low for 1 (Hood) spring-run pop in 1 MPG (Gorge spring-run) above BON. Based on habitat, Low for fall-run populations in 3 fall-run MPGs below BON.
	Subyearling populations above BON: -2.7% (-4.4 to -0.2%) Absolute Difference: -2.4% (-3.8 to -0.2%)			Subyearling populations above BON: -2.7% Absolute Difference: -2.4%	Same (or possibly greater) mainstem habitat effects as SR fall chinook for subyearlings from fall-run populations that spawn above BON (2 of 20 fall-run populations in 1 of 6 MPGs).	Medium for Upper Gorge, Hood, and Big White Salmon fall-run populations in 1 (Gorge fall-run) MPG above BON.
	Populations that spawn below BON: no difference			Populations that spawn below BON: no difference	Less estuarine rearing habitat for summer subyearling migrants from all fall-run populations.	Very Low for 2 populations in 1 MPG (Cascade Spring-run) below BON.

Table 6.8 (continued). Summary of effects of proposed hydro operations and 2004 system configuration on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Steelhead	-10.5% (-30.6 to -1.6%) Absolute Difference: -3.6% (-6.7 to -0.6%)	-1.3% (-3.3 to +0.4%) Absolute Difference: -0.7% (-1.4 to +0.2%	None	-1.3% Absolute Difference: -0.7%	Same as SR spring/summer chinook.	Low (Same rationale as SR sp/sum chinook)
UCR Steelhead	-9.1% (-22.4 to -1.5%) Absolute Difference: -4.7% (-6.9 to -0.8%	N/A	0	-9.1% Absolute Difference: -4.7%	Same as SR spring/summer chinook.	Medium

Table 6.8 (continued). Summary of effects of proposed hydro operations and 2004 system configuration on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
MCR Steelhead	Populations migrating through **4 dams:** -9.1% (-22.4 to -1.5%) Absolute Diff.: -4.7% (-6.9 to -0.8%) **3 dams & pools:** -7.7% (-18.7 to -1.3%) Absolute Diff.: -4.6% (-6.4 to -0.8%) **3 dams:** -4.7% (-10.0 to -1.2%) Absolute Diff.: -3.4% (-7.8 to -0.9) **2 dams:** -3.8% (-9.1 to -0.2%) Absolute Diff.: -2.9% (-7.3 to -0.2) **1 dam**: -2.8% (-6.2 to -0.2% Absolute Diff.: -2.4% (-5.2 to -0.2%)	N/A	0	**4 dams**: -9.1% for 5 populations in 2 MPGs Absolute Diff.: -4.7% **3 dams & pools**: -7.7% for 1 population in 1 MPG Absolute Diff.: -4.6% **3 dams**: -4.7% for 7 populations in 3 MPGs Absolute Diff.: -3.4% **2 dams**: -3.8% for 2 populations in 1 MPG Absolute Diff.:-2.9% **1 dam**: -2.8% Absolute Diff.: -2.4%	Same as SR spring/summer chinook.	Medium for 7 populations in 3 MPGs that spawn between McNary and John Day dams. Medium for 3 populations in 2 MPGs that spawn upstream of McNary Dam. Medium for 2 populations in 1 MPG that spawns downstream of John Day Dam.

Table 6.8 (continued). Summary of effects of proposed hydro operations and 2004 system configuration on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
UWR Steelhead	N/A	N/A	0	N/A	Estuary and plume habitat effects minor, because little difference in flows.	Very Low
LCR Steelhead	Populations migrating through 1 dam: -2.8% (-6.2 to -0.2%) Absolute Difference: -2.4% (-5.2 to -0.2%)	N/A	0	-2.8% for 3 of 20 populations in 2 of 4 MPGs Absolute Difference: -2.4% No difference for the other 17 populations	Same as SR spring/summer chinook	Medium for 4 populations in 2 MPGs that migrate through Bonneville pool and dam Very Low for 16 populations that spawn below BON
CR Chum Salmon	N/A, if chum spawn above Bonneville Dam, but some juveniles migrate through 1 Dam: possibly ~-2.7% survival	N/A	0	~-2.7% if there is an extant population above Bonneville Dam No difference for 7 populations in 3 MPGs	Should have better spawning and rearing habitat, because fall/winter flows higher than in reference operation. Effects on juvenile migration and rearing habitat similar to SR fall chinook, but possibly more significant because of smaller smolt size and greater reliance on estuarine rearing.	Medium (for all populations, because juvenile rearing habitat reduced by lower summer flows and higher temperatures, although spawning and incubation improved by higher fall/winter flows)

Table 6.8 (continued). Summary of effects of proposed hydro operations and 2004 system configuration on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Sockeye Salmon	N/A, assumed to be slightly greater than the difference for SR spring/summer chinook and SR steelhead	N/A	0	Assumed to be slightly greater than the difference for SR spring/summer chinook and SR steelhead	Assumed similar to SR spring/summer chinook and SR steelhead	Low
LCR Coho Salmon and LCR Steelhead	N/A, but expected to be similar to yearling-type LCR chinook populations above BON. No change for all other pops	N/A	0	If similar to yearling-type LCR chinook - 1.6% for 2 populations in 1 MPG No difference for 19 populations in 3 MPGs	Similar to SR spring/summer chinook (minor) for populations that spawn above Bonneville	Low for Upper Gorge and Hood River populations in the Gorge MPG Very Low for remaining 19 populations in 3 MPGs (including 1 below-BON population in the Gorge MPG)

Table 6.9. Summary of effects of proposed hydro operations and expected 2010 system configuration improvements on listed ESUs. Relative (proportional) survival change expressed as (Proposed - Reference) ÷ Reference.

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Spring/ Summer Chinook Salmon	0% (-4.9 to +5.5%) Absolute Difference: 0% (-2.5 to +3.3%)	-0.4% (-2.0 to +1.4%) Absolute Difference: -0.2% (-1.1 to +0.7%)	None	-0.4% Absolute Difference: -0.2%	Minor or no change in mainstem and below-BON estuary and plume habitat is expected, because the 2010 proposed action spring flows are similar to the reference operation flows. Safe passage through barriers improves, based on the juvenile in-river survival estimate, most likely as a result of installation of RSWs and other passage improvements. Little or no change in water quality is expected.	Low

Table 6.9 (continued). Summary of effects of proposed hydro operations and expected 2010 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Fall Chinook Salmon	-1.2%* (-6.5 to +2.1%) to -10.0%** (-18.9 to 0%) Absolute Difference: -0.2%* (-1.2 to +0.7%) to -1.7%** (-3.2 to 0%)	Under range of D-values:*** -1.1 to -2.2% relative system survival difference -2 difference in juveniles below Bonneville per 1000 juveniles arriving at LGR reservoir*** -4,000 difference in juveniles per two million arriving at LGR reservoir***	None	Under range of D-values:*** -1.4 to -2% relative system survival difference -2 difference in juveniles below Bonneville per 1000 juveniles arriving at LGR reservoir*** -4,000 difference in juveniles per two million arriving at LGR reservoir***	Change in mainstem and below-BON habitat expected, because the 2010 proposed action summer flows are considerably less than the reference operation flows. Changes in spill affect safe passage through barriers, although some dam passage improvements improve in-river survival slightly. Possible change in water quality (increased temperature) due to much lower flows in the proposed action.	Low to Medium

* In-river survival sensitivity analysis in which pool survival between MCN and BON is assumed equal in both the reference and proposed operations. This sensitivity analysis was conducted in response to comments because of a lack of empirical reach survival data for SR fall chinook in the lower Columbia River. This difference applies only to the unknown, but small, proportion of the population that migrates entirely in-river.

** In-river survival analysis using SR fall chinook empirical reach survival data from the Snake River, extrapolated to the lower Columbia River using methods described in Appendix D. This difference applies only to the unknown, but small, proportion of the population that migrates entirely in-river.

*** The SR fall chinook in-river survival gap applies only to the unknown, but small, proportion of the population that migrates entirely in-river. Information on the proportion of transported fish and their survival rate is needed to properly weight the in-river results. Transport survival is unknown because the post-Bonneville differential survival (D) is highly uncertain (see Section 5.2.2.3.1.1). However, a reasonable range of potential D-values (0.18 - 0.41) was calculated (Appendix D, Attachment 5; summarized in Section 5.2.2.3.1.1) for use in comparing relative differences between alternative operations.

Table 6.9 (continued). Summary of effects of proposed hydro operations and expected 2010 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
UCR Spring Chinook Salmon	+0.7% (-1.1 to +3.7%) Absolute Difference: +0.5% (-0.6 to +2.9%	N/A	None	+0.7% Absolute Difference: +0.5%	Same as SR spring/summer chinook, with slightly improved survival in 2010 proposed action due to McNary RSW, dam passage improvements and MOP operations in lower Columbia.	(Improve)
UWR Chinook Salmon	N/A	N/A	N/A	N/A	Predominantly yearlings, but also some subyearling migrants. Same as SR spring/summer chinook (minor) for yearlings. Same as or possibly greater mainstem habitat effects than SR fall chinook for subyearlings. Reduction in estuarine rearing habitat in summer for all populations with small subyearling smolts.	Very Low

Table 6.9 (continued). Summary of effects of proposed hydro operations and expected 2010 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
LCR Chinook Salmon	Yearling populations above BON: -1.4% (-1.9 to -0.5%) Absolute Difference: -1.3% (-1.8 to -0.4%) Subyearling populations above BON: -2.6% (-4.3 to -0.1%) Absolute Difference: -2.3% (-3.8 to -0.1%) Populations that spawn below BON: no change	N/A	None	Yearling populations above BON: -1.4% Absolute Difference: -1.3% Subyearling populations above BON: -2.6% Absolute Difference: -2.3% Populations that spawn below BON: no change	Same as SR spring/summer chinook (minor) for yearlings from populations that spawn above Bonneville, with some survival improvements at Bonneville Dam. Same (or possibly greater) mainstem habitat effects as SR fall chinook for subyearlings from fall-run populations that spawn above BON (2 of 20 fall-run populations in 1 of 6 MPGs). Reduction in estuarine rearing habitat in summer subyearling migrants from all fall-run populations.	Low for 1 (Hood) spring-run pop in 1 MPG (Gorge spring-run) above BON. Based on habitat, Low for fall-run populations in 3 fall-run MPGs below BON. Medium for Upper Gorge, Hood, and Big White Salmon fall-run populations in 1 Gorge fall-run MPG above BON. Very Low for 2 populations in 1 MPG (Cascade Spring run) below BON.

Table 6.9 (continued). Summary of effects of proposed hydro operations and expected 2010 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Steelhead	-3.4% (-25.7 to +6.8%) Absolute Difference: -1.2% (-4.4 to +2.7%)	-0.1% (-3.1 to +1.8%) Absolute Difference: -0.1% (-1.3 to +0.9%)	None	-0.1% Absolute Difference: -0.1%	Same as SR spring/summer chinook, except system survival difference in 2010 proposed action decreased due to installation and use of RSWs, and in-river survival also decreased.	Low (Same rationale as SR sp/sum chinook)
UCR Steelhead	-2.9% (-17.2 to +5.1%) Absolute Difference: -1.5% (-4.1 to +2.9%)	N/A	None	-2.9% Absolute Difference: -1.5%	Same as SR spring/summer chinook.	Medium

Table 6.9 (continued). Summary of effects of proposed hydro operations and expected 2010 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
MCR Steelhead	Populations migrating through **4 dams:** -2.9% (-17.2 to +5.1%) Absolute Diff : -1.5% (-4.1 to +2.9%) **3 dams & pools:** -4.5% (-16.1 to +2.2%) Absolute Diff.: -2.7% (-5.2 to +1.4%) **3 dams:** -1.4% (-7.1 to +2.4%) Absolute Diff.: -1.0% (-5.3 to +1.8%) **2 dams:** -1.9% (-7.5 to +1.5%) Absolute Diff.: -1.4% (-5.8 to +1.2%) **1 dam:** -2.4% (-6.0 to 0%) Absolute Diff.: -2.1% (-5.0 to 0%)	N/A	None	Populations migrating through **4 dams:** -2.9% for 5 populations in 2 MPGs Absolute Diff: -1.5% **3 dams & pools**: -4.5% for 7 populations in 3 MPGs Absolute Diff.: -2.7% **3 dams:** -1.4% for 1 population in 1 MPG Absolute Diff.: -1.0% **2 dams:** -1.9% for 2 populations in 1 MPG Absolute Diff.: -1.4% **1 dam:** -2.4% Absolute Difference: -2.1%	Same as SR spring/summer chinook.	Medium for 7 populations in 3 MPGs that spawn between McNary and John Day dams. Medium for 3 populations in 2 MPGs that spawn upstream of McNary Dam. Low for 2 populations in 1 MPG that spawns downstream of John Day Dam.

Table 6.9 (continued). Summary of effects of proposed hydro operations and expected 2010 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
UWR Steelhead	N/A	N/A	None	N/A	Estuary and plume habitat effects minor, because little change in flows.	Very Low
LCR Steelhead	Populations migrating through 1 dam: -2.4% (-6.0 to 0%) Absolute Difference: -2.1% (-5.0 to 0%)	N/A	None	-2.4% for 4 of 20 populations in 2 of 4 MPGs Absolute Difference: -2.1 No change for the other 17 populations	Same as SR spring/summer chinook	Medium for 4 populations in 2 MPGs that migrate through Bonneville pool and dam Very Low for 16 populations that spawn below BON
CR Chum Salmon	N/A, if chum spawn above Bonneville Dam, but some juveniles migrate through 1 Dam: possibly ~ -2.6% survival	N/A	None	~ -2.6 if there is an extant population above Bonneville Dam No change for 7 populations in 3 MPGs	Should have improved spawning and rearing habitat, because fall/winter flows higher than in reference operation. Juvenile migration and rearing habitat effects similar to SR fall chinook, but possibly more significant because of smaller size and greater reliance on estuarine rearing.	Medium (for all populations, because juvenile rearing habitat reduced by low summer flows and higher temperatures, although spawning and incubation improved by higher fall/winter flows

Table 6.9 (continued). Summary of effects of proposed hydro operations and expected 2010 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Sockeye Salmon	N/A, assumed to range between SR spring/summer and fall chinook	N/A	None	Assumed to range between SR spring/ summer and fall chinook	Assumed similar to SR spring/ summer chinook and SR steelhead	Low-Medium (same rationale as SR sp/sum chinook)
LCR Coho Salmon and LCR Steelhead	N/A, but expected to be similar to yearling-type LCR chinook populations above BON. No change for all other pops	N/A	None	If similar to yearling-type LCR chinook -~- -1.4% for 2 populations in 1 MPG Absolute Difference: -1.3% No change for 19 populations in 3 MPGs	Similar to SR spring/summer chinook (minor) for populations that spawn above Bonneville	Low for Upper Gorge and Hood River populations in the Gorge MPG Very Low for remaining 19 populations in 3 MPGs (including 1 below-BON population in the Gorge MPG)

Table 6.10 Summary of effects of proposed hydro operations and expected 2014 system configuration improvements on listed ESUs. Relative (proportional) survival change expressed as (Proposed - Reference) ÷ Reference.

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Spring/ Summer Chinook Salmon	+4.0% (0% to +10.3%) Absolute Difference: +2.2% (0% to +6.1%)	+1.1% (-0.3 to +3.2%) Absolute Difference: +0.6% (-0.2 to +1.7%)	None	+1.1% Absolute Difference: +0.6%	Minor or no change in mainstem and below-BON estuary and plume habitat is expected, because the 2014 proposed action spring flows are similar to the reference operation flows. Safe passage through barriers improves, based on the juvenile in-river survival estimate, as a result of installation of RSWs and other fish passage improvements at all FCRPS dams. Little or no change in water quality is expected.	(Improve)

Table 6.10 (continued). Summary of effects of proposed hydro operations and expected 2014 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Fall Chinook Salmon	+4.1%* (-1.5 to +7.1%) to -5.2%** (-14.5 to +5.3%) Absolute Difference: +0.6% (-0.3 to +1.3%) to -0.9% (-2.5 to +1.2%)	Under range of D-values:*** -0.7 to -1.6% relative system survival difference -1.4 difference in juveniles below Bonneville per 1000 juveniles arriving at LGR reservoir*** -2800 difference in juveniles per two million arriving at LGR reservoir***	None	Under range of D-values:*** -1.0 to -1.5% relative system survival difference -1.4 difference in juveniles below Bonneville per 1000 juveniles arriving at LGR reservoir*** -2800 difference in juveniles per two million arriving at LGR reservoir***	Change in mainstem and below-BON habitat expected, because the 2014 proposed action summer flows are considerably less than the reference operation flows. Changes in spill affect safe passage through barriers, although some dam passage improvements improve in-river survival slightly. Possible change in water quality (increased temperature) due to much lower flows in the proposed action.	Low to Medium

* In-river survival sensitivity analysis in which pool survival between MCN and BON is assumed equal in both the reference and proposed operations. This sensitivity analysis was conducted in response to comments because of a lack of empirical reach survival data for SR fall chinook in the lower Columbia River. This difference applies only to the unknown, but small, proportion of the population that migrates entirely in-river.

** In-river survival analysis using SR fall chinook empirical reach survival data from the Snake River, extrapolated to the lower Columbia River using methods described in Appendix D. This difference applies only to the unknown, but small, proportion of the population that migrates entirely in-river.

*** The SR fall chinook in-river survival gap applies only to the unknown, but small, proportion of the population that migrates entirely in-river. Information on the proportion of transported fish and their survival rate is needed to properly weight the in-river results. Transport survival is unknown because the post-Bonneville differential survival (D) is highly uncertain (see Section 5.2.2.3.1.1). However, a reasonable range of potential D-values (0.18 - 0.41) was calculated (Appendix D, Attachment 5; summarized in Section 5.2.2.3.1.1) for use in comparing relative differences between alternative operations.

Table 6.10 (continued). Summary of effects of proposed hydro operations and expected 2014 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
UCR Spring Chinook Salmon	+2.9% (+0.5 to +7.5%) Absolute Difference: +2.1% (+0.3 to +5.8%)	N/A	None	+2.9% Absolute Difference: +2.1%	Same as SR spring/summer chinook, with improved survival in 2014 proposed action due to installation of surface bypasses at McNary and John Day dams and other fish passage improvements at all dams in lower Columbia.	(Improve)
UWR Chinook Salmon	N/A	N/A	N/A	N/A	Predominantly yearlings, but also some subyearling migrants. Same as SR spring/summer chinook (minor) for yearlings. Same as or possibly greater mainstem habitat effects than SR fall chinook for subyearlings. Reduction in estuarine rearing habitat in summer for all populations with small subyearling smolts.	Very Low

Table 6.10 (continued). Summary of effects of proposed hydro operations and expected 2014 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
LCR Chinook Salmon	Yearling populations above BON: -0.8% (-1.8 to +1.0%) Absolute Difference: -0.8% (-1.7 to +0.9%)	N/A	None	Yearling populations above BON: -0.8% Absolute Difference: -0.8%	Same as SR spring/summer chinook (minor) for yearlings from populations that spawn above Bonneville, with some survival improvements at Bonneville Dam.	Low for 1 (Hood) spring-run pop in 1 MPG (Gorge spring-run) above BON. Based on habitat, Low for fall-run populations in 3 fall-run MPGs below BON.
	Subyearling populations above BON: -2.6% (-4.3 to -0.1%) Absolute Difference: -2.3% (-3.7 to -0.1%)			Subyearling populations above BON: -2.6% Absolute Difference: -2.3%	Same (or possibly greater) mainstem habitat effects as SR fall chinook for subyearlings from fall-run populations that spawn above BON (2 of 20 fall-run populations in 1 of 6 MPGs).	Medium for Upper Gorge, Hood, and Big White Salmon fall-run populations in 1 Gorge fall-run MPG above BON.
	Populations that spawn below BON: no change.			Populations that spawn below BON: no change.	Reduction in estuarine rearing habitat in summer subyearling migrants from all fall-run populations.	Very Low for 2 populations in 1 MPG (Cascade Spring run) below BON.

Table 6.10 (continued). Summary of effects of proposed hydro operations and expected 2014 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Steelhead	-1.3% (-24.8 to +5.5%) Absolute Difference: -0.4% (-4.1 to +4.1%)	-0.1% (-3.1 to +2.2%) Absolute Difference: 0% (-1.3 to +1.1%)	None	-0.1% Absolute Difference: 0%	Same as SR spring/summer chinook, except system survival in 2014 proposed action remained unchanged from 2010 proposed action, while in-river survival difference decreased slightly due to installation and use of RSWs and other fish passage improvements.	Low (Same rationale as SR sp/sum chinook)
UCR Steelhead	-1.5% (-16.6 to +7.9%) Absolute Difference: -0.8% (-3.9 to +4.5%)	N/A	None	-1.5% Absolute Difference: -0.8%	Same as SR spring/summer chinook.	Low

Table 6.10 (continued). Summary of effects of proposed hydro operations and expected 2014 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
MCR Steelhead	Populations migrating through **4 dams:** -1.5% (-16.6 to +7.9%) Absolute Diff : -0.8% (-3.9 to +4.5%) **3 dams & pools:** -3.2% (-15.4 to +5.0%) Absolute Diff.: -1.9% (-5.0 to +3.1%) **3 dams:** -0.1% (-6.4 to +5.1%) Absolute Diff.: -0.1% (-4.7 to +3.8%) **2 dams:** -0.8% (-6.9 to +3.9%) Absolute Diff.: -0.6% (-5.3 to +3.0%) **1 dam:** -1.8% (-5.9 to +1.6%) Absolute Diff.: -1.6% (-5.0 to +1.4%)	N/A	None	Populations migrating through **4 dams:** -1.5% for 5 populations in 2 MPGs Absolute Diff: -0.8% **3 dams & pools**: -3.2% for 7 populations in 3 MPGs Absolute Diff.: -1.9% **3 dams:** -0.1% for 1 population in 1 MPG Absolute Diff.: -0.1% **2 dams:** -0.8% for 2 populations in 1 MPG Absolute Diff.: -0.6% **1 dam:** -1.8% Absolute Difference: -1.6%	Same as SR spring/summer chinook.	Medium for 7 populations in 3 MPGs that spawn between McNary and John Day dams. Low for 3 populations in 2 MPGs that spawn upstream of McNary Dam. Low for 2 populations in 1 MPG that spawns downstream of John Day Dam.

Table 6.10 (continued). Summary of effects of proposed hydro operations and expected 2014 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
UWR Steelhead	N/A	N/A	None	N/A	Estuary and plume habitat effects minor, because little change in flows.	Very Low
LCR Steelhead	Populations migrating through 1 dam: -1.8% (-5.9 to +1.6%) Absolute Difference: -1.6 % (-5.0 to +1.4%)	N/A	None	-1.8% for 3 of 20 populations in 2 of 4 MPGs Absolute Difference: -1.6% No change for the other 17 populations	Same as SR spring/summer chinook	Low for 4 populations in 2 MPGs that migrate through Bonneville pool and dam Very Low for 16 populations that spawn below BON
CR Chum Salmon	N/A, if chum spawn above Bonneville Dam, but some juveniles migrate through 1 Dam: possibly ~ -2.6% survival	N/A	None	~-2.6% if there is an extant population above Bonneville Dam No change for 7 populations in 3 MPGs	Should have improved spawning and rearing habitat, because fall/winter flows higher than in reference operation. Juvenile migration and rearing habitat effects similar to SR fall chinook, but possibly more significant because of smaller size and greater reliance on estuarine rearing.	Medium (for all populations, because juvenile rearing habitat reduced by low summer flows and higher temperatures, although spawning and incubation improved by higher fall/winter flows

Table 6.10 (continued). Summary of effects of proposed hydro operations and expected 2014 system configuration improvements on listed ESUs

ESU	Relative Juvenile In-river Survival Difference	Relative Juvenile System Survival Difference (including latent effects)	Relative Adult Survival Difference	Total Relative Survival Difference (juvenile system survival and adult survival)	Habitat Effects	Qualitative Effect Category
SR Sockeye Salmon	N/A, assumed to range between SR spring/summer and fall chinook	N/A	None	Assumed to range between SR spring/ summer and fall chinook	Assumed similar to SR spring/ summer chinook and SR steelhead	Low Improve (same rationale as SR sp/sum chinook)
LCR Coho Salmon and LCR Steelhead	N/A, but expected to be similar to yearling-type LCR chinook populations above BON. No change for all other pops.	N/A	None	If similar to yearling-type LCR chinook ~-0.8% for 2 populations in 1 MPG Absolute Difference: ~-0.8% No change for 19 populations in 3 MPGs	Similar to SR spring/summer chinook (minor) for populations that spawn above Bonneville	Low for Upper Gorge and Hood River populations in the Gorge MPG Very Low for remaining 19 populations in 3 MPGs (including 1 below-BON population in the Gorge MPG)

6.3 SNAKE RIVER SPRING/SUMMER CHINOOK SALMON

6.3.1 Effect of Proposed Hydro Operations

6.3.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

As described in Section 6.2, proposed hydro operations are expected to produce only a minor difference in effects on habitat function with respect to water quantity, water velocity, and water quality during the spring period when juvenile and adult SR spring/summer chinook salmon migrate through the action area. This is because there is little difference in spring flows resulting from reference and proposed operations (Table 6.3; Appendix D) and because both operations restrict voluntary spill to levels that do not produce harmful dissolved gas levels. The proposed operation does have lower functioning juvenile migration habitat with respect to safe passage past barriers by reducing spill levels from those in the reference operation. However, as described in more detail below, this reduction only affects in-river survivals and the effect on total system survival is minimal (an approximate average difference of only 1.9%).

Proposed hydro operations are expected to have only a minor effect on the quantity and quality of juvenile migration and rearing habitat in the Columbia River estuary and plume during the spring, when SR spring/summer chinook salmon are in these areas. Again, this is because the proposed hydro operation will result in only slightly lower spring flows than in the reference operation, and water quality is unlikely to be affected. As a result, there should be little difference in juvenile migration time through the estuary, predation rates by birds, or in the shape and extent of the Columbia River plume. Yearling chinook salmon have a very low reliance on shallow-water rearing habitat in the Columbia River estuary (Fresh *et al.* 2004). There is likely to be only a minor difference in the amount of shallow-water habitat available to SR spring/summer chinook juveniles based on the small difference in flow between the proposed hydro operation and the reference operation.

6.3.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival

6.3.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration. Under most water conditions, the Action Agencies have proposed delaying the date when SR spring chinook fish are collected and transported until April 20. Prior to that date, all fish collected at the three Snake River collector projects would be returned to the river (Section 6.2.1.4). This change from current operations is consistent with current research information that indicates there is typically no benefit provided from transportation during most of the month of April for wild juvenile SR spring chinook (Williams *et al.* 2004). Although, on an average annual basis, transportation has not been shown to provide any increase in adult returns relative to wild fish that migrated in-river, recent data has shown that transport benefits improve later in the spring season (Williams et al. 2004, Anderson et al. 2004). Williams *et al.* (2004) noted that, in some years transported fish had higher average annual returns than the in-river fish, but in some years lower. Hatchery origin SR spring chinook have on average shown a benefit from transport operations.

Balancing the potential benefits of transportation with the possible risks that this operation poses to long-term diversity of the ESU is challenging. Providing both spill and transportation is a method to balance the potential risks that might arise from relying solely on transportation as a management tool. Spill reduces the percentage of fish transported and increases the survival of the fish migrating in-river. The reference operation provided spill through the month of April in years when the average seasonal flow at Lower Granite Dam was projected to be between 70 to 85 kcfs, and terminated spill on May 1 during these relatively low runoff years. As discussed in Section 6.2.1.4, the proposed action provided spill until April 20 when the seasonal average flow was projected to be less than 85 kcfs but greater than 70 kcfs. The 70 kcfs threshold was chosen to reflect a breakpoint below which in-river survival benefits decrease for spring chinook juvenile migrants. This breakpoint may also be associated with increasing water temperatures, which usually occur during the month of May. In the proposed operation, no spill would be provided at collector dams and all fish collected would be transported under seasonal average flows of less than 70 kcfs. Thus, in the reference operation for transportation, the percentage of SR spring chinook transported during the early spring would be slightly less than in the proposed action.

SIMPAS modeling results indicate that proposed 2004 hydro system operations and configuration with present system configuration and fish passage facilities would reduce the survival of juvenile Snake River spring/summer chinook salmon that remain in-river through the Lower Granite to Bonneville reach by an average of 7.3% compared with the reference operation, with a range of survival reduction from 2.6% to 11% (Table 6.8; Appendix D). Because a large proportion of juvenile migrants are collected and transported past FCRPS dams, there is a much smaller reduction in system survival, which includes direct survival and differential post-Bonneville survival (D) of transported fish. On average, the relative survival difference is 1.9% (range = 0.2-4.7%) (Table 6.8; Appendix D) between system survival under the proposed hydro operation and the reference operation.

No reduction in adult survival is expected as a result of the proposed hydro operation (Appendix D). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative system-survival gap for 2004, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR spring/summer chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.3.1.2.2 Effect of Proposed Hydro Operations and 2010 System Configuration. Based on a survival assessment of the Action Agencies' Updated Proposed Action, NOAA Fisheries adjusted various fish passage parameters in the SIMPAS analysis to reflect proposed juvenile passage improvements expected to be implemented during the life of the biological opinion. The following narrative summarizes the major fish passage parameter changes assumed to be in effect for spring migrants by the 2010 intermediate timeframe.

The Action Agencies propose to improve turbine survival at the FCRPS dams by about 1% through operational changes resulting from the biological index testing program and tailrace egress modifications and changes in turbine design from the various powerhouse upgrade programs (e.g., McNary, Bonneville, and Ice Harbor dams). By 2010, both Lower Granite and John Day dams undergoing turbine index testing were given about a 1% survival increase. These estimates are based upon projected improvements in turbine operations, the draft tube environment, powerhouse operations, and tailrace egress/survival.

Several similar comments were submitted on the September 2004 draft of this Opinion that assert there is a lack of evidence to support these proposed increases in turbine survival. It is NOAA Fisheries' opinion that there are tools available, including Biological Index Testing (BIT), physical modeling of the turbine and draft tube environments and physical modeling of powerhouse operation and tailrace egress, all of which help to ensure the achievement of these improvements. The turbine survival improvements at John Day, McNary and Lower Granite dams are based upon the assumption that the Action Agencies will be able to improve survival through these units to at least a level equal to the survival through turbine units at other FCRPS projects. As further evidence, NOAA Fisheries notes the improvement in turbine survival at the Bonneville First Powerhouse as a result of turbine rehabilitation, where the existing units are being replaced with a minimum gap runner design (USACE 2004).

Spillway survivals were increased at Ice Harbor, McNary and The Dalles dams due to the assumption that a combination of removable spill weirs (RSWs), bulk spill and improved tailrace egress would improve survivals. Because Little Goose presently has high spillway survival, no changes were made to the survival estimates. Spillway survival was increased at The Dalles Dam to account for the continuing spillway improvement program at that project, which includes a 1% improvement for stilling basin modifications and a 1% improvement for a change in spill volume (assuming the high spill efficiencies can be maintained).

Bypass survivals were increased for McNary and John Day dams in response to proposed outfall relocation and improved tailrace egress conditions. Fish passage efficiency was increased at Bonneville Dam in response to the continuation of the fish guidance efficiency (FGE) improvement program at the second powerhouse and sluiceway efficiency was adjusted for the Bonneville Dam corner collector based on preliminary 2004 research data. RSW survivals and efficiencies for Lower Monumental and McNary dams were based on empirical Lower Granite Dam RSW data and assumptions. NOAA Fisheries deviated somewhat from the Lower Granite RSW data with the McNary Dam RSW efficiency assumptions due to the higher flow levels experienced in the lower Columbia River compared to the Snake River. In this case, RSW and spill flow percentages at McNary Dam were maintained within the ranges observed at Lower Granite during the 2002 and 2003 studies.[25]

With expected 2010 system configuration improvements described above, the relative system survival difference for SR spring/summer chinook from the proposed action to the reference operation was roughly 0.4% (ranging from a 2.0% reduction to an improvement of 1.4%) (Table

[25] For example, voluntary spill at McNary was maintained at 30% of total river flow and RSW flow was adjusted to obtain approximately the same fish passage efficiency as calculated by the model for the RSW operating at Lower Granite Dam.

6.9; Appendix D). The reduction in the system survival gap and the absence of an in-river survival gap for SR spring chinook by 2010 (0% [-4.9 to +5.5%]) is due largely to system configuration improvements such as the installation and operation of RSWs at Lower Monumental and McNary dams and various other passage improvements in spillway, turbine, and bypass survivals at several mainstem FCRPS dams.

No reduction in adult survival is expected as a result of the proposed 2010 hydro operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gap, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR spring/summer chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.3.1.2.3 Effect of Proposed Hydro Operations and 2014 System Configuration. Based on a survival assessment of the Action Agencies' Updated Proposed Action, NOAA Fisheries further adjusted various fish passage parameters in the SIMPAS analysis to reflect proposed juvenile passage improvements expected to be implemented during the life of the biological opinion. The following narrative summarizes the major fish passage parameter changes assumed to be in effect for spring migrants by the 2014 long-term timeframe.

By 2014, the Action Agencies propose to increase turbine survival at most FCRPS dams by 1 to 2% through operational changes resulting from the biological index testing program and tailrace egress modifications and changes in turbine design from the various powerhouse upgrade programs (e.g., McNary, Bonneville, and Ice Harbor dams). By 2014, dams undergoing turbine index testing were given a 1% survival increase while those dams with a combination of improvements were given up to a 2% improvement. These estimates are based upon projected improvements to turbine operations, the draft tube environment, powerhouse operations, tailrace egress/survival, and, in the case of McNary and Ice Harbor dams, turbine rehabilitation.

Spillway survival was increased at Lower Monumental Dam due to the assumption that a combination of a removable spill weir (RSW), bulk spill and improved tailrace egress would improve survival at that project. Although Little Goose is expected to have an RSW installed by 2014, it presently has high spillway survival, so no changes were made to its survival estimate.

SIMPAS bypass parameters were modified for the 2014 analysis, resulting in higher survival rates at most mainstem FCRPS Columbia and Snake River dams, in response to proposed bypass system or screen improvements, outfall relocations and improved tailrace egress conditions. For example, fish passage efficiency and survival was increased at Bonneville Dam First Powerhouse due to the completion of a new bypass system and bypass outfall at that project. Fish guidance efficiency was increased at John Day Dam as a result of installing extended-length screens at the powerhouse. Sluiceway survivals were increased at The Dalles and Bonneville dams for some of the same reasons.[26] Survival and efficiency performance of an RSW at Little

[26] Sluiceway passage efficiency at The Dalles Dam was also increased.

Goose Dam was based on empirical passage/survival data and assumptions from the Lower Granite Dam RSW.

With all the expected system configuration improvements implemented by 2014 as described above, the relative system survival difference for SR spring/summer chinook from the proposed action to the reference operation was a +1.1% improvement (ranging from a 0.3% reduction up to a 3.2% improvement in survival) (Table 6.10; Appendix D). The absence of both a system and in-river survival gap for SR spring chinook by 2014 (+4% [0 to +10.3%]) is due largely to implementation of all the proposed system configuration improvements, including installation and operation of RSWs at Little Goose, Lower Monumental, McNary and John Day dams and various other passage improvements in spillway, turbine, and bypass survivals or outfall relocations at various mainstem FCRPS dams.

No reduction in adult survival is expected as a result of the proposed 2014 hydro operation (Table 6.4; Appendix D, Attachment 4). In 2014, the difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival difference, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR spring/summer chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.3.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative “habitat approach” and the quantitative “survival approach” leads NOAA Fisheries to conclude that the proposed hydro operation is likely to reduce abundance and productivity of Snake River spring/summer chinook salmon by a Low amount for all populations and major population groups. It is not likely that the proposed action would reduce distribution or diversity of the ESU.

Using the “environmental baseline approach,” the proposed action is likely to negatively impact essential features of designated critical habitat during the 2004 through 2009 migration seasons. During this period, the essential feature of safe passage conditions in the juvenile migration corridor will be impaired, compared to the reference operation, because the spill rates are lower in the proposed operation. Spill is generally a safer route of passage than other routes, as indicated by the difference in in-river survival estimates between the two operations (Table 6.8). As described in Section 6.3.1.1, water-quality critical habitat essential features, such as temperature and dissolved gas concentration, are not likely to be affected by the proposed action. Similarly, differences in the functioning of critical habitat also are not expected for adult migration corridor features.

Between 2010 and 2014, critical habitat is not likely to be negatively impacted by the proposed action, because the proposed installation of surface passage structures is expected to result in juvenile passage conditions through the FCRPS that are at least as safe as those associated with the reference operation (Tables 6.9 and 6.10).

Under the "listing conditions approach," the proposed action is not likely to negatively alter essential features of critical habitat from conditions existing at the time of listing. The levels of safe passage in both 2004 – 2009 and 2010 – 2014 are higher than that in 1992, when this ESU was listed. See Section 5.2.2.1.1.

6.3.2 Effect of Non-hydro Measures

6.3.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.3.2.1.1 Enhance and Restore Estuarine Habitat. The Action Agencies have proposed that they will implement six specific habitat restoration projects in the upper estuary between Bonneville Dam and the mouth of the Columbia River, for the purpose of improving the survival of juvenile SR fall chinook (see the November 24, 2004 Updated Proposed Action). For BPA funded projects, the Action Agencies identified the status of project funding and implementation time lines by referencing the associated BPA project proposals. For these projects, the proposed action identifies when each project will be completed (completion dates vary from 2006 to 2010).

As more acres are added and restored, the cumulative benefit of the Action Agencies' estuary program could be expected to support the significant benefit assigned to the estuary by Fresh *et al.* (2004) for this ESU. The Northwest Fisheries Science Center has preliminarily estimated that restoration of one-third of the historically accessible acres would be necessary to achieve this response, and it is refining this estimate to more precisely determine the number of acres needed to fully achieve this greater benefit (Appendix E). A critical information gap and uncertainty is how to value the contribution of the proposed habitat restoration actions in the Columbia River estuary to improvements in salmon population production and viability, both for the short and long term. NOAA Fisheries, with support from the Action Agencies, has recently started programs to develop the time series of information regarding salmon use of Columbia River estuarine habitats, with the intent of reducing the uncertainty outlined above. Until that information is available, however, studies have been conducted for the past decade in the Skagit River system in Puget Sound for fall chinook salmon that could provide insight to help quantitatively value the beneficial accrual gained in juvenile salmon productivity (e.g. number of juveniles per acre of habitat) based on improving estuarine habitat. Over the next year, NOAA Fisheries will be evaluating the available data to try to establish the likely range of benefit that could be achieved for Columbia River estuary restoration action. This information will potentially allow NOAA Fisheries to value the benefit of a suite of actions in the Columbia River system to improve salmon population (and ESU) productivity and viability. This information will assist in placing added context to the current benefit of the projects proposed by the Action Agencies and provide future direction on the magnitude, extent, and distribution of estuary restoration projects to be developed by the Action Agencies.

The Action Agencies propose to implement action effectiveness monitoring for selected projects, as well as status monitoring for the estuary as a whole as described in the UPA (IV. Research, Monitoring and Evaluation, p.88).

Snake River spring/summer chinook display a stream-type life history strategy (Fresh et al., 2004) which relies less on estuary habitat to sustain viability than ocean-type ESUs. Since the 2000 FCRPS Biological Opinion, the Action Agencies have developed the infrastructure to begin an estuary and RME program which focuses on the long-term benefit to ESA-listed salmonids through estuary habitat restoration. The six projects the Action Agencies have proposed in their proposed action dated November 24, 2004, are the start of this on-going program. NOAA Fisheries assigned benefits to these projects based on an examination of how these projects relate to each of the ESUs across their entire geographic ranges. The six projects, while having localized and important benefits, are still limited enough in their magnitude, extent, and distribution that a higher benefit cannot be assigned at this time. Therefore NOAA Fisheries concludes that the magnitude, extent, and distribution of the six proposed estuary actions would provide a 0 short-term and a 0 long-term benefit to the Snake River spring/summer chinook ESU. This level of benefit would apply to all populations and major population groups within the ESU.

The proposed action is likely to negatively impact the essential features of designated critical habitat in the upper and lower estuary during July through September in 2006 through 2010. During this period, the essential features associated with juvenile rearing areas (such as cover or shelter, food, water quantity/space) and juvenile migration (such as safe passage) will be impaired compared to the reference operation, because the discharge rates at Bonneville Dam are lower in the proposed operation. Lower discharge rates are likely to reduce the amount of shallow-water habitat available to juvenile salmonids during the summer period. However, shallow-water rearing habitat is less important to stream type populations and ESUs that have short resident times in the estuary. Conversely, shallow-water rearing habitat is important to ocean type populations and ESUs that reside for longer periods of time in the estuary. After 2009, assuming that the six proposed estuary actions mitigate for the approximately 50 to 700 acres of shallow-water habitat (defined by a water depth of 0.1 to 2.0 meters) above RM 35 and the smaller, unquantified loss below, NOAA Fisheries concludes that there is no negative affect of the proposed action on juvenile rearing habitat in the estuary[27].

6.3.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies commit to implement additional Caspian tern management actions to reduce predation of juvenile salmonids in the Columbia River estuary consistent with the objectives of the preferred alternative in the forthcoming joint Corps/USFWS/NOAA Fisheries Final Environmental Impact Statement (FEIS) on Caspian tern management. This action is described in more detail in Section III.D.1 of the Updated Proposed Action.

[27] As identified in Bottom *et al*. (2001), juvenile salmonids have a preference for rearing habitat at certain water depths and locations within the lower Columbia River. Based on an analysis of shallow-water habitat (as defined by water depth between 0.1 and 2.0 meters) above RM35 and some slight but unquantified acreage below RM35, restoring 700 acres that habitat type will be required to avoid a negative effect on critical habitat within that same water depth. The Action Agencies have proposed six restoration projects to mitigate for FCRPS project impacts to juvenile survival for Snake River Fall Chinook in the lower Columbia River.

One option to implement the Record of Decision (ROD) for the Caspian Tern FEIS, once it is signed, would rely solely on Action Agencies for implementation responsibility. The other option designates US Fish and Wildlife Service as the lead implementing agency, but the FCRPS Action Agencies could still provide funding and the Corps would continue to perform operation and maintenance activities on the nesting islands in the estuary (Rice Island, Miller Sands, and East Sand Island). Either way, the activity is appropriate for inclusion in the proposed action because the Action Agencies are either carrying it out or funding it.

The draft joint Corps/USFWS/NOAA Fisheries EIS on Caspian tern management is currently available for public review and comment. The implementation schedule assumes that a Record of Decision (ROD) for the Caspian Tern EIS between the Corps and USFWS will be signed in 2005. NOAA Fisheries is considering this project as part of the UPA.

Based on the projected levels of tern colony size resulting from implementation of alternatives C and D of the draft Tern EIS, NOAA Fisheries estimated the survival improvements for SR spring/summer chinook as approximately 2.3%.[28] NOAA Fisheries concludes that implementation of alternative C or D would result in a Low benefit to SR spring/summer chinook. This level of benefit would apply to all populations and major population groups within the ESU. Efforts to redistribute the Columbia River estuary Caspian tern population could begin in FY05 once the federal agencies complete the final EIS and issue the Record of Decision and could begin producing results (lower predation rates) in FY06. Consequently, NOAA Fisheries anticipates that there will be no short-term benefit from these projects. Therefore, the proposed action for reducing tern predation on East Sand Island will provide 0 short-term but Low long-term (by 2014) survival benefits for SR spring/summer chinook salmon. This level of benefit will accrue to all populations and all major population groups in the ESU.

The Action Agencies' assessment of the benefit (increased survival) to this ESU which would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, compensatory mortality would need to exceed 75% to reduce the contribution of offsetting actions towards filling the hydrosystem survival gap below that anticipated by the Action Agencies from this action. NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

The Action Agencies commit to monitor and evaluate the response to the proposed management action and to submit annual reports of survival benefits to NOAA Fisheries. Performance metrics

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[28] Alternative A is the "no action" alternative and therefore its implementation would not result in lowered tern predation rates. In Alternative B, nesting habitat would not be maintained on East Sand Island. Managers predict that revegetation of the tern nesting area would occur in approximately 2 to 3 years (Dorsey 2004), which would reduce the Caspian tern colony to zero birds. Therefore, the predation rate that would occur under Alternative B has the potential to be less than that of C or D, but timing of habitat reduction is uncertain.

will include annual Caspian tern predation rates on juvenile salmonids and estimates of the resulting juvenile survival rates, although the action agencies do not describe the method(s) they will use to derive these estimates.

The proposed action, including reducing predation by Caspian terns on East Sand Island by relocating them out of the estuary, is expected to have a positive effect on the essential feature of safe passage in designated critical habitat as it relates to the juvenile migration corridor in the estuary.

6.3.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies have implemented a number of tributary habitat projects to benefit this ESU since the 2000 Biological Opinion was issued. As reported in the *2003 Check-in Report*, they have implemented actions that provide near-term survival improvements, including 23 barrier removals, 114 screening diversions, and four lease or purchases of in-stream flows. Long-term survival improvements are also accruing through the implementation of three conservation easements or land acquisitions to protect riparian habitat from degradation and two actions to establish riparian buffers and/or obtain long-term easements to restore riparian habitat.

In the August 30, 2004, version of the Updated Proposed Action, USBR proposed to continue a tributary habitat technical assistance program in three subbasins of the Salmon River drainage, which was instituted under the 2000 RPA (Action 149). This measure is intended to provide an additional increment of overall survival for three populations Snake River spring/summer chinook (i.e., in the Lemhi, Upper Salmon, and Little Salmon subbasins) during their spawning and rearing life stages.[29] NOAA Fisheries concludes that there is a Medium potential to improve spawning and rearing habitat for these three subbasins (Appendix B). USBR considered the primary limiting factors identified by NOAA Fisheries and considered its ability to implement a habitat improvement program that attempted to address those limiting factors. USBR concluded that it does not have the legal authority to implement projects that would protect riparian habitat. USBR has the authority to provide technical assistance to solve engineering issues affiliated with channel morphology. However, it currently does not have authority to fund the construction of such projects (authority to fund construction of instream projects has been introduced in the Congress). USBR can lease or acquire instream flows in compliance with state water law. USBR can also provide technical assistance on channel morphology and screens. Consequently, it formulated this measure as a commitment to continue its current technical assistance program across the three selected subbasins during the first 3-years of the term of this Biological Opinion and achieve the following:

- Design screens for 10 unscreened diversions across the three subbasins during the first 3 years
- Protect 20 cfs of water for instream flows
- Provide technical assistance to restore access to 54 miles of currently unoccupied habitat
- Provide technical assistance to restore 0.25 miles of channel complexity

[29] Absent this measure, Reclamation would be required to withdraw from its current participation in tributary habitat improvements in the Lemhi, Upper Salmon, and Little Salmon Rivers basins due to a lack of funding authority.

Because the USBR lacks authority to implement non-flow related projects, NOAA Fisheries cannot assume that these projects will occur. If these projects are implemented to achieve the metric goals NOAA Fisheries would expect the currently assessed benefits to SR spring/summer chinook to increase commensurate with the effectiveness of the actions. NOAA Fisheries will evaluate the survival benefit of those actions based on information from implementation of the tributary RM&E commitments described in the UPA. NOAA Fisheries assumes that the technical assistance program described as the USBR's measures, along with on-going actions being implemented and documented in the Action Agencies ESA progress reports, will provide Very Low short-term and a Very Low long-term (by 2014) benefit to a small portion of the SR spring/summer chinook salmon ESU.[30]

The Action Agencies' 2003 Progress Report identified habitat improvement actions that they had implemented under the 2000 RPA for the purpose of offsetting adverse hydropower impacts through at least 2010. Some of those actions were implemented in this subbasin. The Action Agencies will ensure these that actions are maintained so that benefits continue over the term of the UPA. Additional details, including metrics that describe the benefits of each action are provided in the UPA. NOAA Fisheries expects that some positive but currently immeasurable level of survival improvement, in addition to that derived from the conservation actions and measures detailed in the UPA, will accrue from each of these actions but has not attempted to quantify that benefit for the purpose of this analysis.

6.3.2.3 Effect of Artificial Propagation Measures

BPA is proposing to continue funding the safety-net planning project and, if necessary, intervene with artificial propagation for severally depressed and declining populations. Given the recent increase in abundance of this ESU, additional safety-net actions are not currently needed. However, implementation of additional safety-net actions for severely depressed populations would be expected to help preserve genetic diversity and increase abundance if such programs were needed in the future. BPA currently funds several actions that fit within the safety-net concept and that were initiated in the mid-to-late 1990s, when numerous populations within this ESU were severely depressed. BPA is funding captive broodstock programs for the Tucannon River and three populations within the Grande Ronde basin (upper Grande Ronde River, Catherine Creek, and Lostine River), a captive rearing program for three populations in Idaho (Lemhi River, East Fork Salmon River, and West Fork Yankee Fork), and Johnson Creek supplementation in Idaho. The captive broodstock programs and Johnson Creek action increased abundance of the target populations. The Catherine Creek captive broodstock program is also providing eggs for reintroduction in Lookingglass Creek. The captive rearing actions in Idaho have focused primarily on research and improving knowledge of how to use the artificial propagation tool. NOAA Fisheries has determined that the safety-net program for this ESU is effective at reducing the short-term risk of extinction. The captive broodstock and rearing actions are being phased out over the next several years, are providing a Low short-term benefit, but will provide no benefit after the programs end. Very Low benefits are possible long-term from the expected increase in abundance if Northeast Oregon Hatchery plans designed to improve the

[30] The USBR's conservation measures will benefit only one or two of the populations in each of two of the five major population groups [South Fork Salmon River and Upper Salmon].

current Grande Ronde hatchery program and increasing the Tucannon smolt releases are implemented.

The Action Agencies also propose to complete the HGMP planning process designed to identify hatchery improvements and reforms that could affect SR spring/summer chinook salmon. However, development of the plan itself will have no direct effect on the viability of this ESU.

6.3.2.4 Effect of Measures to Reduce Fish Predation

The northern pikeminnow has been responsible for approximately 8% predation-related mortality of juvenile salmonid migrants in the Columbia River basin in the absence of the Northern Pikeminnow Management Program (NPMP) (2000 FCRPS BiOp at 9-106). The Action Agencies estimated that the ongoing NPMP, which they propose to continue, has reduced the pikeminnow predation-related mortality rate to approximately 6% (August 30, 2004, Updated Proposed Action p. 43). The Action Agencies estimate that proposed expansion of the NPMP (increasing the pikeminnow exploitation rate from a historical 12% to a potential 15 to 16%) would result in an approximately 0.6% further reduction in predation-related mortality, lowering the overall mortality to an estimated 5.4%. The Action Agencies estimate that this reduction applies to all listed ESUs.

The ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. This is because the modeling estimates are calibrated to empirical reach survival estimates that included the ongoing program. Therefore, although the ongoing NPMP clearly can be considered as a non-hydro offsets that would contribute to improving survival, its effects have already been accounted for in the survival differences included in Tables 6.6 and 6.7.

The additional improvement expected from the expanded NPMP has not been included in the estimates of Tables 6.6 and 6.7, except for the 2001 estimate. Because the increase in the predator removal program in this single year has a minor impact on the mean estimates of the difference between the proposed and reference operations, the effects of the expanded NPMP can be considered as measures that would further improve survival. Several reviewers of the September 9, 2004 draft of this Opinion questioned the use of an increase in the exploitation rate in the NPMP as a quantifiable means to fill the gap between the proposed and reference operations. Specifically, these commenters questioned whether there was a quantifiable relationship between the current pikeminnow exploitation rate and an absolute increase in survival of up to 3 or 4 % as proposed by the Action Agencies. Overlapping confidence intervals between recent exploitation rate estimates indicate that defining a specific quantifiable benefit (e.g., 0.6% estimated in the UPA) is statistically indefensible. On the other hand, several commenters indicated support for the increased program, and most believe that there would be some benefit to migrating juvenile salmonids. It is NOAA Fisheries' opinion that the improved program will result in a Low survival improvement to all listed ESUs.

The presence of reservoirs in the environmental baseline creates areas of slow water velocity that provide beneficial habitat for Northern Pikeminnows. The presence of dams and bypass outfalls in the environmental baseline also concentrates salmon and steelhead, making them more vulnerable to predation by Northern Pikeminnow. These factors reduce the "safe passage" essential feature of juvenile migration corridor critical habitat under the environmental baseline. The proposed action, which removes Northern Pikeminnow from the juvenile migration corridor, would improve the safe passage essential feature of juvenile migration corridor critical habitat.

The Action Agencies also propose to study the possibility of initiating a program of targeted removals of non-indigenous predators, such as smallmouth bass, beginning with a predation workshop in fall 2004. If researchers and policy-makers can agree on testing of removals of nonindigenous predators in key locations such as Lower Granite pool and John Day and The Dalles tailraces, testing could begin as early as 2005. From there, quantification of the benefits associated with nonindigenous predation management could be estimated using existing modeling capabilities. Because the implementation program is not scheduled to begin before the end of year 6 (2010), NOAA Fisheries does not consider it an action that can apply to offsetting the proposed hydro action in this Opinion.

6.3.3 Net Effect of Hydro and Non-hydro Actions

6.3.3.1 Net Effect on Productivity, Abundance, and Distribution

NOAA Fisheries considered the net effect of proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.3.1 and 6.3.2 and summarized in Table 6.11.

In 2004, proposed hydro operations are expected to reduce the survival of all major population groups of SR spring/summer chinook salmon by a Low amount, compared to the reference operation. The mean quantitative survival estimate indicates that the negative effect is at the upper end of the range of Low values (Tables 6.5 and 6.8). Continuation of the Northern Pikeminnow Management Program is already accounted for in the estimation of the hydro survival gap. Expansion of the NPMP is estimated to have a Low positive effect, as described in Section 6.3.2.4. The most optimistic estimate of the positive effect of the expanded NPMP is at the lower end of the range of Low values. Additionally, the safety-net hatchery programs are anticipated to have a positive effect of similar magnitude (Section 6.3.2.3), and habitat improvements in certain tributaries are expected to have a Very Low effect (Section 6.3.2.2). Because the offsetting actions are expected to result in either a Very Low improvement or an improvement at the lower end of the range of Low values, they are unlikely to offset the hydro survival gap, which is at the upper end of the range of Low values. The net effect is a reduction in the abundance, productivity, and possibly distribution of this ESU as a result of the proposed action between 2004-2009.

Table 6.11. Assessment of net effect of Updated Proposed Action for most significant components. Safety-net programs reduce short-term risk of extinction for several ESUs. The difference in the relative hydro survival gap between 2004, 2010, and 2014 is due to hydrosystem improvements phased in during this period. "NC" = no net change in numbers, reproduction, or distribution. "Improve" and "Reduce" refer to net improvement or reduction in numbers, reproduction, or distribution.

ESU	Major Population Groups (MPGs)	Year	(-) Relative Hydro Survival Gap (% survival difference and qual. est. including habitat effects)	(+) Estuary Habitat	(+) Tributary Habitat	(+) Fish Predation	(+) Bird Predation	(+) Hatchery	Σ(+) Combined Non-hydro Improve-ment	(=) MPG Net Effect	ESU Net Effect
SR Spring/ Summer Chinook	All	2004	-1.9% (L)	0	VL	L	0	L	L	Reduce	Reduce (Short-term)
		2010	-0.4% (L)	0	VL (*for a few populations*)	L	L	VL	L to M	NC to Improve	
		2014	+1.1% (Improve)	0	VL (*for a few populations*)	L	L	VL	L to M	Improve	

Table 6.11 (Continued). Assessment of net effect of Updated Proposed Action for most significant components.

ESU	Major Population Groups (MPGs)	Year	(-) Relative Hydro Survival Gap (% survival difference and qual. est. including habitat effects)	(+) Estuary Habitat	(+) Tributary Habitat	(+) Fish Predation	(+) Bird Predation	(+) Hatchery	Σ(+) Combined Non-hydro Improve-ment	(=) MPG Net Effect	ESU Net Effect
SR Fall Chinook	Only One	2004	-8.4% to -16.6% in-river;* -2 to -3% system with range of "D" (= -3 to -4 fish below BON per 1000 @ LGR pool)** + estuary habitat impact (M - Low End)	0	0	L	0	L	L	Reduce	Reduce (Short-term)
		2010	-1.2% to -10% in-river;* -1% to -2% system with range of "D" (= -2 fish below BON per 1000 @ LGR pool)** + estuary habitat impact (L - High End to M - Low End)	M (*Low End*)	0	L	L	L	M	NC to Improve	
		2014	-5.2 to +4.1% in-river;* -1.0 to -1.5% system with range of "D" (-1.4 below BON per 1000 @ LGR pool)** + estuary habitat impact (L - High End to M - Low End)	M (*Low End*)	0	L	L	L	M	NC to Improve	

* Mean in-river survival difference for the unknown, but small, proportion of SR fall chinook juveniles migrating entirely in the river. Range reflects sensitivity analyses for assumptions about the relationship between flow and survival in the lower Columbia River. Analysis assumes that all migrants are subyearlings. If 25% of the population migrates as yearlings, the range would be 8-14%.

** The SR fall chinook in-river survival gap applies only to the unknown, but small, proportion of the population that migrates entirely in the river. Information regarding the proportion of transported fish and their survival rate is needed to properly weight the in-river results. As described in Section 5. 2.2.3.1.1, transport survival is unknown because the post-Bonneville differential survival (D) is highly uncertain. However, a reasonable range of potential D-values (0.18 - 0.41) was calculated (Appendix D, summarized in Section 5.2.2.3.1.1) for use in comparing relative differences between alternative operations. Mean relative difference in system survival and mean difference in number of juveniles below Bonneville in proposed action, compared to reference operation, per 1000 juveniles entering Lower Granite reservoir. If two million juveniles enter Lower Granite reservoir, the difference would be ~6000fish in 2004 and ~4000 fish in 2010. The differences in relative survival rates and numbers are based on subyearling migration strategy and existence of a flow/survival relationship in the lower Columbia River that is extrapolated from empirical reach survival estimates in the lower Snake River. Differences would be lower under alternative assumptions.

Table 6.11 (Continued). Assessment of net effect of Updated Proposed Action for most significant components.

ESU	Major Population Groups (MPGs)	Year	(-) Relative Hydro Survival Gap (% survival difference and qual. est. including habitat effects)	(+) Estuary Habitat	(+) Tributary Habitat	(+) Fish Predation	(+) Bird Predation	(+) Hatchery	Σ(+) Combined Non-hydro Improve-ment	(=) MPG Net Effect	ESU Net Effect
UCR Spring Chinook	Only One	2004	-5.8% (M)	0	VL	L	0	0	L	Reduce	Reduce (Short-term)
		2010	+0.7% (Improve)	0	M (*Low End*)	L	L	0	M	Improve	
		2014	+2.9% (Improve)	0	M (*Low End*)	L	L	0	M	Improve	
LCR Chinook	Cascade Spring MPG (0 dams)	2004	VL	0	0	0	0	0	0	NC	Reduce (Short-term) for up to 4 MPGs
		2010	VL	0	0	0	L	0	L	Improve	
		2014	VL	0	0	0	L	0	L	Improve	
	Gorge Spring MPG (1 dam)	2004	-1.6% (L)	0	0	L	0	0	L	Reduce	
		2010	-1.4% (L)	0	0	L	L	0	L to M	NC to Improve	
		2014	-0.8% (L)	0	0	L	L	0	L to M	NC to Improve	
	3 Fall MPGs (0 dams)	2004	Estuary habitat impact (VL)	0	0	0	0	0	0	NC	
		2010	Estuary habitat impact (VL)	M (*Low End*)	0	0	L	0	M	NC to Improve	
		2014	Estuary habitat impact (VL)	M (*Low End*)	0	0	L	0	M	NC to Improve	
	Gorge Fall MPG (1 dam)	2004	-2.7% + estuary habitat impact (M)	0	0	L	0	0	L	Reduce	
		2010	-2.6% (M)	M (*Low End*)	0	L	L	0	M	NC to Improve	
		2014	-2.3% (M)	M (*Low End*)	0	L	L	0	M	NC to Improve	

Table 6.11 (Continued). Assessment of net effect of Updated Proposed Action for most significant components.

ESU	Major Population Groups (MPGs)	Year	(-) Relative Hydro Survival Gap (% survival difference and qual. est. including habitat effects)	(+) Estuary Habitat	(+) Tributary Habitat	(+) Fish Predation	(+) Bird Predation	(+) Hatchery	Σ(+) Combined Non-hydro Improve-ment	(=) MPG Net Effect	ESU Net Effect
UWR Chinook	All	2004	VL	0	0	0	0	0	0	NC	NC
		2010	VL	0 (for yearlings) M (for subs)	0	0	L	0	L for Yearlings; M for Subs	Improve	
		2014	VL	0 (for yearlings) M (for subs)	0	0	L	0	L for Yearlings; M for Subs	Improve	
SR Steelhead	All	2004	-1.3% (L)	0	VL	L	0	0	L	Reduce	Reduce (Short-term)
		2010	-0.1% (L)	0	VL *(for a few populations)*	L	M	0	M	Improve	
		2014	-0.1% (L)	0	VL *(for a few populations)*	L	M	0	M	Improve	
UCR Steelhead	Only One	2004	-9.1% (M)	0	VL	L	0	0	L	Reduce	Reduce (Short-term)
		2010	-2.9% (M)	0	M (*Low End*)	L	M	0	M	NC to Improve	
		2014	-1.5% (L)	0	M (*Low End*)	L	M	0	M	NC to Improve	

Table 6.11 (Continued). Assessment of net effect of Updated Proposed Action for most significant components.

ESU	Major Population Groups (MPGs)	Year	(-) Relative Hydro Survival Gap (% survival difference and qual. Est. including habitat effects)	(+) Estuary Habitat	(+) Tributary Habitat	(+) Fish Predation	(+) Bird Predation	(+) Hatchery	Σ(+) Combined Non-hydro Improve-ment	(=) MPG Net Effect	ESU Net Effect
MCR Steelhead	1 pop of Cascade E. Slope MPG (1 dam)	2004	-2.8% (M)	0	0	L	0	0	L	Reduce	Reduce (Short-term)
		2010	-2.4% (M)	0	0	L	M	0	M	NC to Improve	
		2014	-1.8% (L)	0	0	L	M	0	M	NC to Improve	
	3 pops of Cascade E. Slope MPG (2 dams)	2004	-3.8% (M)	0	0	L	0	0	L	Reduce	
		2010	-1.9% (L)	0	0	L	M	0	M	Improve	
		2014	-0.8% (L)	0	0	L	M	0	M	Improve	
	John Day MPG (3 dams)	2004	-4.7% (M)	0	VL	L	0	0	L	Reduce	
		2010	-1.4% (L)	0	VL	L	M	0	M	NC to Improve	
		2014	-0.1% (L)	0	VL	L	M	0	M	NC to Improve	
	1 pop of WW/Um. MPG (3 dams+)	2004	-7.7% (M)	0	VL	L	0	VL	L	Reduce	
		2010	-4.5% (M)	0	VL	L	M	VL	M	NC to Improve	
		2014	-3.2% (M)	0	VL	L	M	VL	M	NC to Improve	
	Yakima MPG and 3 pops of WW/Um. MPG (4 dams)	2004	-9.1% (M)	0	0	L	0	VL	L	Reduce	
		2010	-2.9% (M)	0	0	L	M	VL	M	NC to Improve	
		2014	-1.5% (M)	0	0	L	M	VL	M	NC to Improve	
UWR Steelhead	All	2004	VL	0	0	0	0	0	0	NC	NC
		2010	VL	0	0	0	M	0	M	Improve	
		2014	VL	0	0	0	M	0	M	Improve	

Table 6.11 (Continued). Assessment of net effect of Updated Proposed Action for most significant components.

ESU	Major Population Groups (MPGs)	Year	(-) Relative Hydro Survival Gap (% survival difference and qual. Est. including habitat effects)	(+) Estuary Habitat	(+) Tributary Habitat	(+) Fish Predation	(+) Bird Predation	(+) Hatchery	Σ(+) Combined Non-hydro Improve-ment	(=) MPG Net Effect	ESU Net Effect
LCR Steelhead	2 MPGs (0 dams)	2004	VL	0	0	0	0	0	0	NC	Reduce (Short-term) for 2 MPGs
		2010	VL	0	0	0	M	0	M	Improve	
		2014	VL	0	0	0	M	0	M	Improve	
	2 MPGs (mostly 1 dam)	2004	-2.8% (M)	0	0	L	0	VL	L	Reduce	
		2010	-2.4% (M)	0	0	L	M	VL	M	NC to Improve	
		2014	-1.8% (L)	0	0	L	M	VL	M	NC to Improve	
CR Chum	1 MPG (1/2 pops 1 dam)	2004	Estuary habitat and possible hydro impacts M	0	0	L	0	0	L	Reduce to NC	Reduce (short-term) to NC
		2010	Estuary habitat and possible hydro impacts (M)	M (*Low End*)	0	L	VL	0	M	Improve	
		2014	Estuary habitat and possible hydro impacts (M)	M (*Low End*)	0	L	VL	0	M	Improve	
	2 MPGs (0 dams)	2004	Estuary habitat impact (VL)	0	0	0	0	VL	VL	NC	
		2010	Estuary habitat impact (VL)	M (*Low End*)	0	0	VL	VL	M	Improve	
		2014	Estuary habitat impact (VL)	M (*Low End*)	0	0	VL	VL	M	Improve	

Table 6.11 (Continued). Assessment of net effect of Updated Proposed Action for most significant components.

ESU	Major Population Groups (MPGs)	Year	(-) Relative Hydro Survival Gap (% survival difference and qual. Est. including habitat effects)	(+) Estuary Habitat	(+) Tributary Habitat	(+) Fish Predation	(+) Bird Predation	(+) Hatchery	Σ(+) Combined Non-hydro Improve-ment	(=) MPG Net Effect	ESU Net Effect
LCR Coho	2 MPGs (0 dams)	2004	VL	0	0	0	0	0	0	NC	Reduce (Short-term)
		2010	VL	0	0	0	M	0	M	Improve	
		2014	VL	0	0	0	M	0	M	Improve	
	1 MPG (2/3 pops 1 dam)	2004	-1.6 to -2.8% (M)	0	0	L	0	0	L	Reduce	
		2010	-1.4 to -2.4% (M)	0	0	L	M	0	M	NC to Improve	
		2014	-0.8 to -1.8% (L)	0	0	L	M	0	M	NC to Improve	
SR Sockeye	Only One	2004	-1.3 to -1.9% (L)	0	0	L	0	M	M	Improve	NC
		2010	-0.1 to -0.4% (L)	0	0	L	0 (*no info*)	M	M	Improve	
		2014	-0.1 to +1.1% (L to Improve)	0	0	L	0 (*no info*)	M	M	Improve	

By 2010, the Action Agencies' propose to complete structures that will improve fish passage at mainstem FCRPS dams, further reducing the impact of proposed hydro improvement actions to a very small net difference in average system survival, compared to the reference operation (Tables 6.6 and 6.9) for all major population groups. In addition to offsetting actions that will be in place in 2004, the Action Agencies propose to implement the preferred alternative for estuarine avian predation reduction, which is expected to result in a Low survival improvement for all major population groups (Section 6.3.2.1.2). By 2010, it is likely that the combination of all proposed actions will result in no net change, or possibly an improvement, in the abundance, productivity, or distribution of this ESU.

6.3.3.2 Net Effect on Essential Features of Critical Habitat

6.3.3.2.1 2004-2009 Period. The net effect of the proposed action is to negatively impact an essential feature of designated critical habitat from 2004 through 2009 under the "environmental baseline approach." As described in Section 6.3.1.3, the "safe passage" essential feature in the juvenile migration corridor during this period is likely to be impaired, compared to the reference operation, because the spill rates are lower in the proposed operation. The immediate expansion of the pikeminnow removal program (6.3.2.4) during this same period partially offsets this adverse effect. This is because the baseline existence of FCRPS dams and reservoirs creates low-velocity habitat conducive to pikeminnows, especially near dams where juvenile salmon and steelhead are concentrated, leading to high predation rates. The pikeminnow removal program reduces that predation, thereby creating safer passage conditions. The expanded pikeminnow program only partially offsets the effect of reduced spill because, to the extent that safe passage habitat conditions can be evaluated by the survival rate of fish through that habitat (in-river survival rate gap of Table 6.8), the magnitude of the survival improvement associated with the pikeminnow program in the proposed action is less than the magnitude of the survival reduction associated with the proposed spill operation.

To the extent that juvenile mortality in the hydrosystem causes some difference in the number of adult SR spring/summer chinook returning to their natal tributaries, it will affect nutrient cycling in spawning and rearing areas compared to the reference operation. Because functional and quantitative relationships between returning adults, marine derived nutrients, and essential features of critical habitat are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for habitat designated as critical for SR spring/summer chinook salmon is largely inferential, as discussed in Section 5.2.3.

The proposed action also includes immediate activities that will improve tributary habitat (Section 6.3.2.2). These activities are likely to improve the functioning of critical elements of spawning and juvenile rearing habitat that are occupied by a few of the 31 extant populations of SR spring/summer chinook salmon. These improvements to critical habitat in tributaries partially offset the alteration of critical habitat in the juvenile migration corridor, because they affect critical habitat occupied by the same ESU. These improvements are only a partial offset because they improve only a small proportion of spawning and rearing habitat used by the ESU, whereas the proposed action results in alteration of a significant proportion of the juvenile migration corridor critical habitat.

Under the "listing conditions approach," the proposed action is not likely to negatively impact essential features of critical habitat from conditions existing at the time of listing. The levels of safe passage in 2004 – 2009 are higher than that in 1992, when this ESU was listed. See Section 5.2.2.1.1.

6.3.3.2.2 2010-2014 Period. As described in Section 6.3.1.3, juvenile migration corridor critical habitat is not likely to be negatively impacted by the proposed action under the "environmental baseline approach," as indicated by the in-river survival rates of Tables 6.9 and 6.10. Furthermore, reduction of avian predation in the estuary and fish predation within the FCRPS will improve safe passage through the juvenile migration corridor, resulting in a net improvement in functioning of juvenile migration corridor critical habitat. In addition, habitat improvements in selected tributaries will improve functioning of spawning and juvenile rearing critical habitat occupied by a small proportion of the ESU. Altogether, an improvement in the functioning of critical habitat affecting various life stages of SR spring/summer chinook salmon is expected.

Under the "listing conditions approach," the proposed action is not likely to negatively impact essential features of critical habitat from conditions existing at the time of listing. The levels of safe passage in 2010 – 2014 are higher than that in 1992, when this ESU was listed. See Section 5.2.2.1.1.

6.4 SNAKE RIVER FALL CHINOOK SALMON

6.4.1 Effect of Proposed Hydro Operations

6.4.1.1 Effect of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

As described in Section 6.2, proposed hydro operations are expected to reduce habitat function with respect to water quantity and water velocity during the summer period when juvenile SR fall chinook salmon migrate through the action area when compared to the theoretical reference operation. This is because there is a substantial difference in summer flows resulting from the reference and proposed operations (Table 6.3; Appendix D). The proposed operation also reduces the functioning of juvenile migration habitat with respect to safe passage past barriers by reducing spill levels from those in the reference operation, which are described below. Water quality may be impacted because the reduced summer flows may result in higher temperatures in the migration corridor. This can increase the rate of predation by fish such as Northern Pikeminnow.

Habitat conditions for adult migrants and for spawning and rearing habitat are expected to either remain unchanged or improve, because flow is expected to be higher during the fall and winter in comparison to reference operation flows.

Proposed hydro operations are expected to have a small effect on the quantity and quality of juvenile migration and rearing habitat in the Columbia River estuary and plume during the summer, when SR fall chinook salmon are in these areas (Section 6.2.1.1). As a result, there may be small differences in juvenile survival and migration time through the estuary and in the shape and extent of the Columbia River plume. As the ocean-type SR fall chinook salmon smolt and migrate as subyearlings, much of their growth and development occurs above Lower Granite Dam (Connor *et al.* 2003). As a result, SR fall chinook more closely resemble yearling chinook salmon by the time they reach the estuary (Fresh *et al.* 2004).

In addition, Connor *et al*. 2004 indicate the existence of an alternative life history for SR fall chinook, e.g., a reservoir-type SR fall chinook, which migrates as a yearling smolt. Accordingly, yearling chinook salmon rely on shallow-water rearing habitat in the Columbia River below Bonneville Dam, as well as shallow water habitat in the lower estuary (Fresh *et al*. 2004). Using the "environmental baseline approach," there is likely to be a reduction in the amount of shallow-water habitat available to SR fall chinook juveniles in the upper estuary between Bonneville Dam and RM 35 and a small but unquantifiable reduction below RM 35 because of the change in summer flow. This reduction should have a slight but significant impact on this ESU.

6.4.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival.

6.4.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration. The Action Agencies' proposed transport operation is to maximize the collection and transportation of juvenile fall chinook and initiate an evaluation of fall chinook transportation with more favorable in-river passage conditions at Snake River collector projects beginning in 2007/2008. In order to maximize transportation, the proposed operation calls for no spill at all collector projects and transportation of all fish collected. The proposed action includes flow augmentation and spill at lower Columbia River projects equivalent to that included in the 2000 FCRPS Biological Opinion.

The proposed operation is identical to the reference operation relative to the strategy of maximizing transportation of juveniles (Section 5.2.1.1.2). Under both the proposed action and the reference operation, a little less than half of the fish arriving at the head of Lower Granite pool are expected to end up on barges (Table 15 of Appendix D). This estimated percentage of transported fish is subject to uncertainty about survival prior to reaching transport sites, including uncertainty regarding the percentage of fish that may residualize as yearlings rather than continuing their migration as subyearlings. Recent information indicates that a significant proportion of returning adults is composed of fish that emigrated as yearlings rather than subyearlings (Connor *et al.* 2004), suggesting that some fish may over-winter within the hydrosystem. If these fish migrate in-river the following spring as yearlings, then their in-river survival rate is likely to be similar to that of SR spring/summer chinook salmon. If these fish are transported as yearlings during the following year, the proportion of transported SR fall chinook is under-estimated.

For the fish that are barged, survival is identical under the proposed and reference operations. Therefore, there is no difference in survival, compared to the reference operation, for approximately half of the juveniles in this ESU. NOAA Fisheries did not attempt to estimate the survival rate of transported fish because of great uncertainty regarding their differential survival below Bonneville Dam relative to that of non-transported fish. Although the specific survival of transported fish is unknown and was not estimated, it is likely that the same survival rate would apply to fish transported under both the proposed and reference operations.

For the juvenile SR fall chinook that are not barged, the main differences between the reference and proposed operations are lower flow rates in the proposed action, especially through lower Columbia River reservoirs that are at higher elevations than minimum operating pool in the proposed action, and less spill at two lower Columbia River projects in the proposed action than in the reference operation. Thus, most of the impacts on survival apply only to that small proportion of the population that is not transported and that survives to migrate through the lower Columbia River.

Modeling results indicate that proposed hydro operations would result in lower in-river survival, compared to that which would be expected under the reference operation. The in-river survival rates presented in Table 6.5 apply only to the small proportion of fish that migrate entirely in the river to Bonneville Dam. A large proportion of the fish that are not barged die while migrating to collector sites and experience different in-river survival rates, depending upon the point of transportation. These fish are likely to die at the same rate in the reference and proposed operations, because the main difference between the two operations affects survival primarily in the lower Columbia River below all the transportation collector projects.

Because the SR fall chinook in-river survival gap described in Table 6.8 applies only to the unknown but small proportion of the population that migrates entirely in the river, it is difficult to evaluate the significance of the in-river survival difference without further information. Information regarding the proportion of transported fish and their survival rate is needed to properly weight the in-river results. As described in Section 5. 2.2.3.1.1, transport survival is unknown because the post-Bonneville differential survival (D) is highly uncertain. However, a reasonable range of potential D-values (0.18 - 0.41) was calculated (Appendix D, Attachment 5, summarized in Section 5.2.2.3.1.1) for use in comparing relative differences between alternative operations. As described in Tables 6.8 and 6.11, under a range of reasonable D-values, the 2004 proposed operation is expected to result in an average of three to four fewer fish below Bonneville Dam for each 1000 fish arriving at the head of Lower Granite reservoir. This results in about a 6000-fish difference compared to the reference operation, if the population arriving at the head of Lower Granite Reservoir is on the order of two million juveniles. Under the range of D-values, Table 6.8 shows the relative system survival (transported + in-river) difference would be a reduction between 2 and 3%. The mortality associated with proposed hydro operations is expected to affect the single population of Snake River fall chinook salmon, and that mortality is expected to begin immediately.

Tables 6.8 and 6.11 display a range of differences in the in-river survival rate of the small proportion of fish that migrate entirely in-river to Bonneville. The High end of the range is based on extrapolation of Snake River empirical reach survival estimates to the lower Columbia River, in order to derive a lower Columbia River flow/survival relationship for reservoir survival. While it is likely that there is an influence of flow on reservoir survival in the lower Columbia, there are no empirical reach survival estimates for this portion of the river, so the quantitative impact of differences in flow is highly uncertain. The Low end of the range indicates the difference in survival that would occur if there were no effect of flow on reservoir survival in the lower Columbia River. If there is no influence of flow on reservoir survival through the lower Columbia River, the difference in in-river survival is reduced by about half for the 2004 operation.

The range of in-river survival estimates considered only the subyearling life history phase and did not include any additional survival that would be afforded the yearling life history. The survival of the yearling phase of SR fall chinook would likely be much higher, because they would migrate at a larger size and under cooler water conditions in the following year. Accordingly, their survival rates would likely be closer to that of yearling SR spring/summer chinook. To estimate this effect on the SR fall chinook gap analysis, NOAA Fisheries conducted a sensitivity analysis by assuming various proportions of the fall chinook population exhibiting either the subyearling and yearling life history.

To obtain an estimate of what proportion of each life history to use, NOAA Fisheries requested the USFWS provide an estimate. In response to this request, B. Connor provided a memo with a description of the method and assumptions he used to create such estimates (B. Connor memo dated 10-29-04). The USFWS memo provided estimates of the subyearling-yearling proportions based on estimates of fish tagged in the mainstem Snake River over the last five years. The Clearwater River segment of the population, however, was not included in these estimates. Given the later migration timing of the Clearwater population, NOAA Fisheries adjusted the proportion of fish exhibiting a yearling life history phase to a 50:50 ratio as the upper end of an expected range of subyearling-yearling proportions.

If, for example, it is assumed that 25% of the SR fall chinook juveniles over-winter and then out-migrate the following spring (with a survival rate similar to that of SR spring/summer chinook), the upper end of the estimated in-river survival gap in 2004 for these fish would be reduced from 16.6% to a new value of about 14%. Similarly, assuming 50% of SR fall chinook juveniles over-winter and migrate out the following spring results in an estimated in-river survival gap of 12%.

The estimates of in-river survival in Table 6.5 do not include potential latent mortality of in-river migrants. As discussed in Section 5. 2.2.3.1.1, the magnitude of this mortality is unknown but is expected to be the same in both the proposed and the reference operations. If it is equal in both operations, the effects cancel out when the relative survival difference is estimated.

No difference in adult survival is expected as a result of proposed 2004 hydro operations (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem compared to the reference operation. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for SR fall chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.4.1.2.2 Effect of Proposed Hydro Operations and 2010 System Configuration Improvements. Based on a survival assessment of the Action Agencies' UPA, NOAA Fisheries adjusted various fish passage parameters in the SIMPAS analysis to reflect proposed juvenile passage improvements expected to be implemented during the life of the biological opinion. The following narrative summarizes the major fish passage parameter changes assumed to be in effect for SR fall chinook migrants by 2010.

The Action Agencies propose to improve turbine survival at the FCRPS dams by about 1-2% through operational changes resulting from the biological index testing program and tailrace egress modifications and changes in turbine design from the various powerhouse upgrade programs (e.g., McNary, Bonneville, and Ice Harbor dams). By 2010, Lower Granite, McNary and John Day dams have undergone turbine biological index testing, which results in 1%, 1% and 9% turbine survival increases, respectively. The John Day Dam survival estimate was a much larger increase than at the other dams as a result of the Corps' proposal to focus turbine survival improvement efforts at this project, which has a much lower summer turbine survival (only 72%) than any other mainstem FCRPS dam. These estimates are based upon projected improvements in turbine operations, the draft tube environment, powerhouse operations, and tailrace egress/survival.

Several similar comments were submitted on the September 2004 draft of this Opinion in which reviewers asserted there is a lack of evidence to support these proposed increases in turbine survival. It is NOAA Fisheries' opinion that there are tools available, including Biological Index Testing (BIT), physical modeling of the turbine and draft tube environments and physical modeling of powerhouse operation and tailrace egress, all of which help to ensure the achievement of these improvements. The turbine survival improvements at John Day and McNary dams are based upon the assumption that the Action Agencies will be able to improve survival through these units to a level at least equal to the current survival level through turbine units at other FCRPS projects. As further evidence, NOAA Fisheries notes the improvement in turbine survival at the Bonneville First Powerhouse turbine rehabilitation, where the existing units are being replaced with a minimum gap runner design (USACE 2004).

Spillway survivals were increased at Ice Harbor and McNary dams due to a combination of improvements including removable spill weirs (RSWs), bulk spill and improved tailrace egress. Spillway survival was also increased at The Dalles Dam to account for the continuing spillway improvement program at that project, which includes a 1% improvement for stilling basin modifications and a 1% improvement for a change in spill volume (assuming the high spill efficiencies can be maintained).

Bypass survivals were increased for McNary and John Day dams in response to proposed outfall relocation and improved tailrace egress conditions. Fish passage efficiency was increased at Bonneville Dam in response to the continuation of the fish guidance efficiency (FGE) improvement program at the second powerhouse.

Modeling results of the 2010 proposed operation and system configuration indicate that, as with the 2004 analysis, a nearly identical proportion of juvenile SR fall chinook (less than half) would be transported under both the reference and proposed operations (Table 58 of Appendix D). As in the 2004 analysis, the survival of transported fish in both the proposed and reference operation would be identical. For the small proportion of juveniles that migrate entirely in the river to below Bonneville, proposed intermediate-term hydro improvements and operations would reduce the difference in in-river survival relative to the reference operation from that estimated for the 2004 operation (Table 6.9; Appendix D). The range of in-river survival estimates in Table 6.9 and the difference between operations in Table 6.9 reflect uncertainty regarding the relationship between flow and survival, as described above. The estimates of in-river survival in Table 6.9 do not include latent mortality of in-river migrants. As discussed above and in Section 5.2.2.3.1.1, it is expected that any latent mortality of in-river migrants is identical in each operation, so it would cancel out in the estimation of the survival difference in Table 6.9.

As noted for the 2004 analysis, the difference in survival for the ESU as a whole would be much less than that described for the in-river migrants, based on a reasonable range of D-value estimates. As described in Table 6.9, the 2010 operation is expected to result in an average of 1 to 2% relative reduction in mean system survival and about two fewer fish below Bonneville Dam for each 1000 fish arriving at the head of Lower Granite reservoir. This results in about a 4000-fish difference if the population arriving at the head of Lower Granite reservoir is on the order of two million juveniles.

These results are based on an assumption of a subyearling life history. As noted above, if NOAA Fisheries conducts a sensitivity analysis of the subyearling-yearling life history phase for the 2010 survival gap analysis, assuming that 25% of the SR fall chinook juveniles over-winter and outmigrate the following spring (with a survival rate similar to that of SR spring/summer chinook), the upper end of the estimated relative in-river survival gap in 2010 for these fish would be reduced from 10% to a new value of between 7 and 8%. Similarly, assuming 50% of SR fall chinook juveniles over-winter and outmigrate the following spring results in an estimated in-river survival gap in 2010 of 5%.

No reduction in adult survival is expected as a result of the proposed 2010 hydro operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gap, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR fall chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.4.1.2.3 Effect of Proposed Hydro Operations and 2014 System Configuration Improvements. Based on a survival assessment of the Action Agencies' UPA, NOAA Fisheries adjusted various fish passage parameters in the SIMPAS analysis to reflect proposed juvenile passage improvements expected to be implemented during the life of the biological opinion. The following narrative summarizes the major fish passage parameter changes assumed to be in effect for SR fall chinook migrants in the 2010-2014 timeframe.

Turbine passage survival rates were increased for all dams from Little Goose Dam down to McNary Dam in response to both operational and hardware improvements mentioned above under yearling chinook (Section 6.3.1.2). Bypass and sluiceway survivals were increased at the same projects for the same reasons as for yearling chinook. Fish passage efficiency was increased at Bonneville Dam due to the completion of the first powerhouse bypass system. Fish guidance efficiency was increased at John Day Dam due to the installation of extended-length screens at the powerhouse.

Modeling results of the 2014 proposed operation and system configuration indicate that, as with the 2004 and 2010 analyses, a nearly identical proportion of juvenile SR fall chinook (less than half) would be transported under both the reference and proposed operations (Table 59 of Appendix D). As in the 2004 and 2010 analyses, the survival of transported fish in both the proposed and reference operations would be identical. For the small proportion of juveniles that migrate entirely in the river to below Bonneville, the proposed long-term (2014) hydro improvements and operations would lower the difference in in-river survival relative to the reference operation from that estimated for the 2004 operation (Table 6.10; Appendix D). The range of in-river survival estimates in Table 6.10 and the difference between operations in Table 6.10 reflect uncertainty regarding the relationship between flow and survival, as described above. The estimates of in-river survival in Table 6.10 do not include latent mortality of in-river migrants. As discussed above and in Section 5.2.2.3.1.1, it is expected that any latent mortality of in-river migrants is identical in each operation, so it would cancel out in the estimation of the survival difference in Table 6.10.

As noted for the 2004 and 2010 analyses, the difference in survival for the ESU as a whole would be much less than that described for the in-river migrants, based on a reasonable range of D-value estimates. As described in Table 6.10, the 2014 operation is expected to result in an average of less than 1% to 1.6% relative reduction in mean system survival and between one and two fewer fish below Bonneville Dam for each 1000 fish arriving at the head of Lower Granite reservoir, compared to the reference operation. This results in about a 2800-fish difference if the population arriving at the head of Lower Granite reservoir is on the order of two million juveniles.

These results are based on an assumption of a subyearling life history. As noted above, if NOAA Fisheries conducts a sensitivity analysis of the subyearling-yearling life history phase for the 2014 survival gap analysis, assuming that 25% of the SR fall chinook juveniles over-winter and outmigrate the following spring (with a survival rate similar to that of SR spring/summer chinook), the upper end of the estimated relative in-river survival gap in 2014 for these fish would be reduced from 5% to a new value of about 3%. Similarly, assuming 50% of SR fall chinook juveniles over-winter and outmigrate the following spring results in an estimated in-river survival gap in 2014 of about 0.6%.

As described in the 2004 analysis, no difference in adult survival is expected as a result of proposed hydro operations (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gap, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR fall chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.4.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative "habitat approach" and the quantitative "survival approach" leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of Snake River fall chinook salmon by a Medium amount for the single population in this ESU in 2004-2009 and by a Low to Medium amount by 2010-2014. It is not likely that the proposed action would reduce distribution or diversity of the ESU. The "Medium" reduction would be at the lowest end of the range, based on the likely effects to the ESU as a whole indicated by the 2-3% relative system survival difference under a range of D-values and based on the relatively small difference in fish numbers.

The proposed hydro operations are likely to alter designated critical habitat throughout the entire period of the proposed action under the "environmental baseline approach." The essential element of safe passage conditions in the juvenile migration corridor will be impaired, compared to the reference operation, because the spill rates at lower Columbia River projects and flows, especially through lower Columbia River projects that are operated at higher elevation, are lower in the proposed operation. Spill is generally a safer route of passage than other routes, and flows speed migration rates, reducing susceptibility to predation. The reduction in the safe passage essential feature is indicated by the difference in survival estimates, for the proportion of fish that migrate entirely in-river, between the reference and proposed operations (Tables 6.8, 6.9, and 6.10). It is unlikely that the water quality essential feature would be impaired with respect to temperature or dissolved gas in the juvenile migration corridor. As described in Section 6.4.1.1, there will also be a slight reduction in the extent of juvenile shallow-water rearing habitat in the estuary, but this is expected to have a relatively minor effect on SR fall chinook salmon, because the magnitude of the effect is small. Habitat conditions for adult migrants and for spawning and rearing habitat are expected to either remain unchanged or improve, because flow is expected to be higher during the fall and winter in comparison to reference operation flows.

Under the "listing conditions approach," the proposed action is not likely to negatively alter essential features of critical habitat from conditions existing at the time of listing. The levels of safe passage and for estuarine rearing habitat in both 2004 – 2009 and 2010 – 2014 are at least as high as that in 1992, when this ESU was listed. See Section 5.2.2.1.1.

6.4.2 Effect of Non-hydro Measures

6.4.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.4.2.1.1 Enhance and Restore Estuarine Habitat. The Action Agencies' proposed action for estuarine habitat improvements is described in section 6.3.2.1.1. Snake River fall chinook exhibit an ocean-type life history strategy (Fresh *et al*. 2004), which puts more reliance on rearing in estuarine habitat to sustain population viability than does the stream-type life-history strategy.

Ocean-type chinook salmon use shallow-water habitat as subyearlings and expand into deeper-water estuarine habitat as yearlings. The specific use of estuarine habitat varies by ocean-type ESU; whereas CR chum salmon rear in the lower portion of the estuary, SR fall chinook probably rear in tidally-influenced freshwater habitat in the upper estuary, the reach between Bonneville Dam and RM 40. Studies are on-going to determine the extent of their habitat use throughout both the upper and lower estuary. Since the 2000 FCRPS Biological Opinion, the Action Agencies have developed the infrastructure to begin an estuary and RME program which focuses on the long-term benefit to ESA-listed salmonids through estuary habitat restoration. The six projects the Action Agencies have proposed in their proposed action dated November 24, 2004, are the start of this on-going program. NOAA Fisheries assigned benefits to these projects based on an examination of how these projects relate to each of the ESUs across their entire geographic ranges. The six projects, while having localized and important benefits, are still limited enough in their magnitude, extent, and distribution that a higher benefit cannot be assigned at this time. Because none of these projects is completed at this time, this Opinion is unable to assign short-term benefit to them but anticipates at least a Medium (very Low end of the range) long-term benefit for SR fall chinook. This level of benefit would accrue to the single remaining population.

As more acres are added and restored, the cumulative benefit of the Action Agencies' estuary program, and other regional and local efforts, could be expected to fully support the Medium ranking of importance assigned to the estuary by Fresh *et al.* 2004 for this ESU. The Northwest Fisheries Science Center is working to further refine how any acres should be encompassed in the one-third estimates of acres needed to be restored to fully achieve a program response (Appendix E). A critical information gap and uncertainty is how to value the contribution of the proposed habitat restoration actions in the Columbia River estuary to improvements in salmon population production and viability, both for the short- and long-term. NOAA Fisheries, with support from the action agencies, has recently started programs to develop the time series of information regarding salmon use of Columbia River estuarine habitats, with the intent of reducing the uncertainty outlined above. Until that information is available, however, studies have been conducted for the past decade in the Skagit River system in Puget Sound for fall chinook salmon that could provide insight to help quantitatively value the beneficial accrual gained in juvenile salmon productivity (e.g. number of juveniles per acre of habitat) based on improving estuarine habitat. Over the next year, NOAA Fisheries will be evaluating the available data to try to establish the likely range of benefit that could be achieved for Columbia River estuary restoration action. This information will potentially allow NOAA Fisheries to value the benefit of a suite of actions in the Columbia River system to improve salmon population (and ESU) productivity and viability. This information will assist in placing added context to the current benefit of the projects proposed by the Action Agencies and provide future direction on the magnitude, extent, and distribution of estuary restoration projects to be developed by the Action Agencies.

The proposed action is likely to negatively affect the essential features of designated critical habitat in the upper and lower estuary during July, August, and September from 2005 through 2009 using the "environmental baseline approach." During this period, the essential features associated with juvenile rearing areas (such as cover or shelter, food, water quantity/space) and juvenile migration (such as safe passage) will be impaired, compared to the reference operation, because the discharge rates at Bonneville Dam are lower in the proposed operation. Lower discharge rates are likely to reduce the amount of shallow-water habitat available to juvenile salmonids during the summer period. Shallow water rearing habitat is less important to stream type populations and ESUs that have short resident times in the estuary. Conversely, shallow-water rearing habitat is important to ocean type populations and ESUs that reside for longer periods of time in the estuary. After 2009, assuming that the six proposed estuary actions mitigate for the approximately 50 to 700 acres of shallow-water habitat (defined by a water depth of 0.1 to 2.0 meters) above RM 35 and the smaller unquantified loss below, NOAA Fisheries concludes that there is no negative affect of the proposed action on juvenile rearing habitat in the estuary.[31]

6.4.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. Direct estimates of tern predation rates on fall run chinook ESUs are not available. However, Fresh *et al.* (2004) state that tern predation has probably affected the viability of ocean-type ESUs, but less than for stream-type ESUs. Fresh *et al.* (2004) concluded that terns have a Low effect on ocean-type ESUs (approximately 2%). Therefore, implementation of alternative C or D in the Draft Joint EIS is expected to result in a Low benefit to Snake River fall chinook. This level of benefit would apply to all populations and major population groups within the ESU. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

Efforts to redistribute the Columbia River estuary Caspian tern population could begin in FY05 and could begin producing results in FY06. Consequently, NOAA Fisheries anticipates that there will be no short-term benefit from these projects. Therefore, the proposed action for reducing tern predation on East Sand Island will provide 0 short-term and Low long-term (by 2014) benefits to SR fall chinook. This level of benefit would accrue to the single remaining population.

The proposed action, including reduced predation by Caspian terns as a result of relocating them out of the estuary, is expected to have a positive effect on the essential feature of safe passage in designated critical habitat as it relates to the juvenile migration corridor in the estuary.

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[31] As identified in Bottom *et al.* (2001), juvenile salmonids have a preference for rearing habitat at certain water depths and locations within the lower Columbia River. Based on an analysis of shallow water habitat (as defined by water depth between 0.1 and 2.0 meters) above RM35 and some slight but unquantified acreage below RM35, restoring a range of 50 to 700 acres that habitat type will be required to avoid a negative effect on critical habitat within that same water depth. The Action Agencies have proposed six restoration projects to mitigate for FCRPS project impacts to juvenile survival for Snake River Fall Chinook in the lower Columbia River.

6.4.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies do not propose any non-hydro offsets in spawning and rearing areas used by Snake River fall chinook. NOAA Fisheries concludes no benefit to population or ESU viability from this type of non-hydro offset for this ESU.

6.4.2.3 Effect of Artificial Propagation Measures

The Action Agencies propose to fund an appropriate share of the operation and maintenance costs associated with the fall chinook salmon trapping program at Lower Granite Dam. They also propose to fund improvements to the adult trap to enhance the benefits associated with current operations.

Hatchery actions, including operation of the Nez Perce Tribal Hatchery, helped preserve genetic diversity and increased total numbers of adults in this ESU since it was listed in the early 1990s. In recent years, both hatchery- and natural-origin adult numbers have increased to several thousand fish each, and the hatchery actions are believed to have contributed to this increase. However, long-term effects on natural-origin sustainability remain an unknown. Improvements to the adult trap and its continued operation at Lower Granite Dam will help provide adults for Nez Perce Tribal Hatchery broodstock, allow an increase in natural-origin fall chinook to be incorporated into hatchery broodstocks, improve the ability to prevent out-of-basin hatchery-origin fall chinook salmon (primarily from the BPA-funded Umatilla Hatchery) from breeding with SR fall chinook, and accommodate critical research and monitoring of this ESU.

In the near term, continued trap operation will provide broodstock for the Nez Perce Tribal Hatchery, which will allow this program to continue contributing to increasing the total number of adults returning to the Snake River basin. It will also allow the trap and removal of out-of-basin hatchery stray fall chinook (preserving genetic diversity) and provide for the continued monitoring and research of the ESU. Collectively, these near-term benefits to the ESU of adult trap and the Nez Perce Tribal Hatchery operations are low.

In the long term, improving the Lower Granite adult trap will accommodate increased collection of fall chinook salmon hatchery broodstock, allow natural origin fish to be incorporated in increased numbers, provide the necessary broodstock for full operation of fall chinook acclimation facilities at Cedar Flat on the lower Selway River and Lukes Gulch on the lower South Fork Clearwater River (both satellite facilities of the Nez Perce Tribal Hatchery), and increase the number of out-of-basin hatchery stray fall chinook that can be trapped and removed. Operation of the Cedar Flat and Lukes Gulch acclimation facilities is expected to expand the distribution of fall chinook into currently unutilized habitat and, if successful, should improve diversity as these fish adapt to new habitat. Collectively, these benefits will provide a Low benefit to the ESU but would be additive to those described for the short term.

6.4.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

As described in Section 6.3.2.4, the presence of dams and reservoirs in the environmental baseline provides good Northern Pikeminnow habitat, thereby reducing the "safe passage" essential feature of juvenile migration corridor critical habitat. The proposed action, which removes Northern Pikeminnow from the juvenile migration corridor, would improve the safe passage essential feature of juvenile migration corridor critical habitat.

6.4.3 Net Effect of Hydro and Non-hydro Actions

6.4.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.3.1 and 6.3.2 (Table 6.8).

Compared to the reference operation, proposed hydro operations are expected to reduce the in-river survival of the single major population group of SR fall chinook salmon in 2004 by a Medium amount. This effect is expected to be at the lowest end of the Medium range, because, while the relative change in survival of those migrants that remain in-river to Bonneville is higher, only a small proportion of the population will be affected. Evaluation of system survival, which affects the entire population, indicates that the relative survival difference is on the order of 2-3% under a range of D-values. Expansion of the Northern Pikeminnow Management Program and the existing supplementation programs are the only immediate offsetting actions. Each of these is expected to have a Low positive effect. On balance, at the beginning of the implementation period for this proposed action, there will likely be a net reduction in the numbers, productivity, and possibly also the distribution of this ESU compared to the reference operation (Table 6.8).

A sensitivity analysis to an assumption of no effect of flow on survival in the lower Columbia River, in response to comments about lack of empirical reach survival data in this area, does not change this conclusion. The proportion of SR fall chinook that migrate as yearlings would have to be greater than 50% to significantly reduce the impact on fish that migrate entirely in-river and, as described in Appendix D, that proportion of yearling migrants is unlikely. Similarly, because relatively few fish migrate through the lower Columbia River, there is little effect of this assumption on the range of system survival estimates.

By 2010, the Action Agencies' have proposed to complete structures and make passage facility improvements that would improve fish passage survival at mainstem FCRPS dams, and these improvements are expected to have a beneficial effect on those relatively few fish that migrate in-river. Because the vast majority of SR fall chinook will be collected and transported under the proposed hydro operation, there is less effect on overall SR fall chinook survival. However, the estimates of the gap in system survival under a range of D-values is decreased to approximately 2% or less, which is consistent with the Low classification or the very lowest end of the Medium range. In addition to the immediate offsetting actions, the Action Agencies propose to implement the preferred alternative developed in the Record of Decision for Caspian tern management, which is expected to result in a Low survival improvement, and to restore some estuarine habitat, which is expected to result in a Medium survival improvement for the single major population group of SR fall chinook salmon. The combination of these improvements would result in a Medium improvement that would be of equal or greater magnitude than the Medium reduction in survival through the hydro system (Tables 6.9, 6.10, and 6.11). Therefore, the combination of expected improvements by 2010 would likely result in no net reduction, or possibly an improvement, in the numbers, reproduction, or distribution of this ESU as a result of the proposed action. Improvements would be most likely to occur if there is little or no effect of flow on survival in the lower Columbia River, or if a significant percentage of SR fall chinook migrate as yearlings, instead of subyearlings.

6.4.3.2 Net Effect on Essential Features of Critical Habitat

6.4.3.2.1 2004-2009 Period. The net effect of the proposed action is alteration of designated critical habitat from 2004 through 2009 using the "environmental baseline approach." As described in Section 6.3.1.3, the "safe passage" essential feature in the juvenile migration corridor during this period is likely to be impaired, compared to the reference operation, because the spill rates at lower Columbia River projects and flows, especially through lower Columbia River projects that are operated at higher elevations, are lower in the proposed operation. The reduction in the safe passage essential feature is indicated by the difference in survival between the reference and proposed operations for the fish that migrate entirely in the river (Table 6.8). The immediate expansion of the pikeminnow removal program (6.3.2.4) during this same period partially offsets this alteration. This is because the baseline existence of FCRPS dams and reservoirs creates low-velocity habitat conducive to pikeminnows, especially near dams where juvenile salmon and steelhead are concentrated, leading to high predation rates. The pikeminnow removal program reduces that predation, thereby creating safer passage conditions. The expanded pikeminnow program only partially offsets the effect of reduced spill and flow, because, to the extent that safe passage habitat conditions can be evaluated by the survival rate of fish through that habitat, the magnitude of the survival improvement associated with the pikeminnow program in the proposed action is less than the magnitude of the survival reduction associated with the proposed spill operation.

This conclusion regarding safe passage is not affected by assumptions regarding the existence of a relationship between flow and survival in the lower Columbia River. Even under an assumption of no effect of flow on survival through the lower Columbia River, the magnitude of the proposed improvements would not offset the reduction in the in-river survival rate, relative to the reference operation. Similarly, this conclusion would only change if a high percentage of the population migrated as yearlings, instead of subyearlings.

There will also be a slight reduction in the extent of juvenile shallow-water rearing habitat in the estuary during this period, as a result of reduced flows compared to the reference operation. This effect is expected to be relatively minor because of the magnitude of the acreage affected.

To the extent that juvenile mortality in the hydrosystem causes some difference in the number of adult SR fall chinook returning to their natal spawning and rearing areas, it will affect nutrient cycling in spawning and rearing areas compared to the reference operation. Because functional and quantitative relationships between returning adults, marine derived nutrients, and essential features of critical habitat are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for habitat designated as critical for SR fall chinook salmon is largely inferential, as discussed in Section 5.2.3.

Under the "listing conditions approach," the proposed action is not likely to negatively alter essential features of critical habitat from conditions existing at the time of listing. The levels of safe passage and for estuarine rearing habitat in 2004 – 2009 are at least as high as those in 1992, when this ESU was listed. See Section 5.2.2.1.1.

6.4.3.2.2 2010-2014 Period. As described in Section 6.4.1.3, the "safe passage" essential element of juvenile migration corridor critical habitat is likely to be altered by the proposed action during 2010-2014, but to a lesser degree than expected during 2004-2009, again using the "environmental baseline approach." Reduction of pikeminnow and avian predation will improve safe passage through the juvenile migration corridor, partially offsetting the reduction in safe passage past FCRPS projects caused by lower spill at lower Columbia River projects and lower flow, especially at lower Columbia reservoirs operated above MOP, than in the reference operation. Estuarine habitat improvements would also affect safe passage by providing cover and shelter for migrating SR fall chinook salmon, and this action is expected to have a positive impact on this essential feature. The combination of these actions is not expected to completely offset the alteration of critical habitat, because the magnitude of the improvement in safe passage is not equivalent to the reduction, compared to the reference operation, for in-river migrants passing through designated critical habitat (Tables 6.9, 6.10, and 6.11). There is some uncertainty in this conclusion, because the impact of the proposed action on safe passage is further reduced if there is no effect of flow on survival in the lower Columbia River or if a significant proportion of SR fall chinook migrate as yearlings, rather than as subyearlings.

The reduction, relative to the reference operation, in shallow-water estuary habitat is likely to be offset by the estuary habitat improvement projects. As described in Section 6.4.1.1, the extent to which juvenile shallow-water rearing habitat in the estuary will be reduced is small and the quality of the lost habitat is unknown. Although the extent of habitat improvement projects is small, these projects are of high quality and are likely to sufficiently offset the reduction in shallow-water estuarine habitat needed by SR fall chinook salmon.

Under the "listing conditions approach," the proposed action is not likely to negatively alter essential features of critical habitat from conditions existing at the time of listing. The levels of safe passage and for estuarine rearing habitat in 2010 – 2014 are at least as high as those in 1992, when this ESU was listed. See Section 5.2.2.1.1.

6.5 UPPER COLUMBIA RIVER SPRING CHINOOK SALMON

6.5.1 Effect of Proposed Hydro Operations

6.5.1.1 Effect of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

As described in Section 6.2, proposed hydro operations, when compared with the theoretical reference operation, are expected to have only a minor effect on habitat function with respect to water quantity, water velocity, and water quality during the spring period when juvenile and adult UCR spring chinook salmon migrate through the action area. The proposed operation does reduce the functioning of juvenile migration habitat with respect to safe passage past barriers due to lower spill levels from those in the reference operation. The magnitude of this habitat modification is significant, as reflected in results of quantitative modeling of in-river survival, which are described below.

Proposed hydro operations are expected to have only a minor effect on the quantity and quality of juvenile migration and rearing habitat in the Columbia River estuary and plume during the spring, when UCR spring chinook salmon are in these areas. Habitat effects in the estuary are essentially the same as those described for SR spring/summer chinook salmon in Section 6.3.

6.5.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival.

6.5.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration. Modeling results indicate that proposed 2004 hydro operations and current system configuration, when compared to the reference operation, would result in a relative reduction in the in-river survival of juvenile UCR spring chinook salmon between McNary Dam and Bonneville Dam that averages 5.8%, with reduced survivals ranging from 2.6% to 8.5% (Table 6.8; Appendix D). The mortality associated with the proposed near-term hydro operations is expected to affect all populations of UCR spring chinook salmon equally, and that mortality is expected to begin immediately.

No difference in adult survival is expected between the proposed 2004 hydro operations and the reference operation (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative system-survival gap for 2004, described above). Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of UCR spring chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.5.1.2.2. Effect of Proposed Hydro Operations and 2010 System Configuration Improvements. For UCR spring chinook, the relative in-river survival change from the intermediate-term 2010 proposed operation and system configuration, compared to the reference operation, decreases substantially to a 0.7% survival improvement (ranging from an estimated 1.1% reduction to a 3.7% improvement in survival) (Table 6.9; Appendix D). This reduction in the survival gap for UCR spring chinook by 2010 is due to proposed system configuration improvements such as: a) installation and operation of two RSWs at McNary Dam; and b) various improvements in spillway, turbine and bypass survivals at all four lower Columbia River dams, as described for SR spring/summer chinook in Section 6.3.1.2.2.

No reduction in adult survival is expected as a result of the proposed 2010 hydro operation (Table 6.4; Appendix D, Attachment 4). In 2010, the difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gap, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of UCR spring chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.5.1.2.3. Effect of Proposed Hydro Operations and 2014 System Configuration Improvements. For UCR spring chinook, the relative in-river survival change from the 2014 long-term proposed operation and system configuration compared to the reference operation increases to a 2.9% survival improvement (with a range from 0.5% to 7.5% improvement) (Table 6.10; Appendix D). This improvement in relative survival for UCR spring chinook by 2014 is due to system configuration improvements such as: a) installation and operation of surface bypasses at both McNary and John Day dams; and b) various improvements in spillway, turbine and bypass survivals at all four lower Columbia River dams, as described for SR spring/summer chinook in Section 6.3.1.2.3.

No reduction in adult survival is expected as a result of the proposed 2014 hydro operation (Table 6.4; Appendix D, Attachment 4). By 2014, the difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gap, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of UCR spring chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.5.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative "habitat approach" and the quantitative "survival approach" leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of UCR spring chinook salmon by a Medium amount for all populations and the single major population group between 2004 and 2009. However, between 2010 and 2014, the proposed action is expected to improve survival through the FCRPS, thereby improving abundance and productivity. It is not likely that the proposed action would reduce distribution or diversity of the ESU**.**

6.5.2 Effect of Non-hydro Measures

6.5.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.5.2.1.1 Enhance and Restore Estuarine Habitat. Like SR spring/summer chinook salmon, UCR spring chinook display a stream-type life history strategy (Fresh *et al.* 2004). The six estuary habitat projects proposed by the Action Agencies will have the greatest benefit for ocean-type life history strategies and ESUs, although they may have some potential to provide off-channel refugia for the Upper Columbia River spring chinook stream-type salmonids. As described in section 6.3.2.1.1, the magnitude, extent, and distribution of the proposed estuary actions are expected to provide a 0 benefit to yearling chinook migrants (in the case of UCR spring chinook, this level of benefit would apply to all the populations and the single major population group). The full benefit to be derived from these six projects will accrue over the term of the Biological Opinion. Thus, the proposed action for estuary habitat restoration will provide 0 short-term and a 0 long-term (by 2014) benefit to the UCR spring chinook. This level of benefit will accrue to all the populations in the single major population group.

6.5.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary and the resulting expected benefit for yearling UCR chinook migrants (0 short-term; Low long-term [by 2014]) are described in section 6.3.2.1.2. This level of benefit will accrue to all the populations in the single major population group. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.5.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies have proposed a tributary habitat program on non-Federal lands which they feel will improve overall survival for the ESU during its spawning and rearing life stages. This program will include projects which address the following limiting factors: 1) fish entrainment, 2) instream flow deficiencies, 3) compromised channel morphology, and 4) riparian condition (Table 6.12). The Action Agencies state that these limiting factors will be addressed in the following manner. Fish entrainment at screens may be addressed through adding new screens, modifying existing screens to meet current criteria, or eliminating the diversion through replacement wells or other means. Instream flow projects include lease or purchase of streamflow, water conservation projects which yield actual "wet water" instream which may be secured through state water law. Not counted in this metric are gaging stations or other water measurement initiatives or investigations which may be necessary to support the evaluation and protection of instream flows for fish. Channel morphology projects include access projects which provide fish passage at structures or conditions that create migration barriers including diversion dams, culverts, low-flow channels, etc. Stream complexity restoration projects include side channel connectivity, flood plain connectivity, channel reconfiguration, large woody debris placement, etc. Riparian protection projects include acquisition of riparian easements or purchases. Riparian enhancement projects include streambank stabilization and riparian treatments such as fencing or reconstruction.

Table 6.12. Proposed action, upper Columbia spring chinook, Wenatchee, Entiat, and Methow subbasins. (from Updated Proposed Action, 30 August 2004)

Limiting Factor	Metric Measurement	Metric Goal in three years	Cumulative Metric Goal in six years
Entrainment	a. Number of screens addressed	5	10
Instream flow projects	a. Cubic Feet per Second (cfs) of water protected for instream flows	12 cfs	40 cfs
Channel Morphology	a. Miles of access restored	60 miles	105 miles
	b. Miles complexity restored	5 miles	10 miles
Riparian Protection	a. Number of miles protected	4 miles	12 miles
Enhancement	b. Number of miles enhanced.	6 miles	12 miles

This program is explained more fully in Section III. D. 4 of the Updated Proposed Action. Summarizing that section, the Action Agencies propose to address the following limiting factors across the subbasins listed:

Wenatchee: The Action Agencies will focus on projects which address changes in channel morphology which includes floodplain connectivity, entrainment, and riparian enhancement.

Entiat: The Action Agencies will focus on projects which address changes in channel morphology in the lower river to include improvements to stream complexity and channel connectivity. The Action Agencies state that other channel morphology improvements are anticipated in other reaches of the subbasin.

Methow: The Action Agencies will primarily focus on projects which address changes in channel morphology with additional projects to effect limited improvements to instream flow. Some riparian protection and enhancement projects are also proposed.

Although the Action Agencies do not identify their commitments in the form of discrete projects across these subbasins they do provide specific commitments in the form of three- and six-year performance measures across these subbasins. The Action Agencies have adopted habitat metrics to increase the certainty and specificity of offsetting habitat improvements. The Action Agencies state that these habitat metrics will be used to increase their accountability for specific targets and further define the expected level of effort needed for ESU-specific survival improvement. The Action Agencies have developed an initial set of performance measures for tributary habitat improvements that are expressed as goals for changes in physical habitat conditions for targeted ESUs. Through an adaptive management loop grounded in a structured monitoring program the Action Agencies commit to a more sophisticated means to measure biological performance and the effectiveness of habitat actions (UPA page 13). The Action Agencies have committed to achieving the survival improvements intended by the UPA in three steps: 1) achieve interim metric goals which the Action Agencies believe will achieve the biological improvements, based on current science, 2) verify that expected survival improvements are achieved through implementation of a tributary RM&E program, and 3) revise the initial habitat performance metrics, as necessary, to ensure that the tributary program achieves the survival improvements intended by the UPA using information from the tributary RM&E program.

The Action Agencies state that, based on their analysis, the total proposed habitat improvements in the Wenatchee, Entiat, and Methow subbasins from achieving the habitat metric goals will fulfill the Medium habitat improvement potential. NOAA Fisheries cannot evaluate the Action Agencies' analyses leading to these conclusions since these are not included as part of the proposed action. NOAA Fisheries does not agree with the Action Agencies approach to arriving at non-hydro benefit (Appendix B, step 9, Updated Proposed Action, November 24, 2004).

In its qualitative analysis of the proposed action for the Upper Columbia spring Chinook, NOAA Fisheries' evaluation included consideration of 1) the categories of actions identified in the cumulative performance metric goal commitments relative to the significant limiting factors identified for these populations in Appendix E, 2) the distribution and severity of limiting factors across the three populations comprised by this ESU, and 3) the Action Agencies commitments to ensure that the tributary program achieves the survival improvements intended by the UPA, as described above. NOAA Fisheries believes that, if the performance metrics are achieved by directing projects at the identified factors limiting Upper Columbia River spring chinook, the aggregate benefit will address a Medium [Low end of range] survival gap. NOAA Fisheries considered those tributary UCR spring/summer chinook projects implemented by the Action Agencies as identified in the PCTS since 2000 and, assuming an ongoing commitment of funds for O&M or RM&E, determined that they would provide a Very Low immediate benefit. Therefore, if the proposed metric goals are achieved at three and six years, NOAA Fisheries concludes that the proposed non-hydro offset program for Upper Columbia River spring chinook that is capable of addressing a low-Medium survival gap will be in place by 2010. This conclusion relies on the Action Agencies commitments to ensuring that these metric goals will achieve the survival improvements intended by the UPA through the adaptive management process above.

The Action Agencies commit to implement a habitat effectiveness monitoring program in the Methow subbasin to confirm that the survival improvement goals are achieved. They expect this program to inform them about the survival effects of habitat improvement projects for this ESU. RM&E actions in the Updated Proposed Action will include an effects monitoring program for some of the projects implemented as part of the tributary proposed action. The Action Agencies commit to adapting the mix and locations to meet metric goals when subbasin and recovery plans, other peer-reviewed information, and RME results indicate that a different mix would be more beneficial to fish populations in the ESUs addressed in the tributary proposed action.

The Action Agencies' 2003 Progress Report identified habitat improvement actions that they had implemented under the 2000 RPA for the purpose of offsetting adverse hydropower impacts through at least 2010. Some of those actions were implemented in this subbasin. The Action Agencies will ensure these that actions are maintained so that benefits continue over the term of the UPA. Additional details, including metrics that describe the benefits of each action are provided in the UPA. NOAA Fisheries expects that some positive but currently immeasurable level of survival improvement, in addition to that derived from the conservation actions and measures detailed in the UPA, will accrue from each of these actions but has not attempted to quantify that benefit for the purpose of this analysis.

6.5.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing to complete the HGMP planning process designed to identify hatchery improvements and reforms which could affect UCR spring chinook salmon. However, development of the plan itself will have no direct effect on the viability of this ESU.

6.5.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

6.5.3 Net Effect of Hydro and Non-hydro Actions

6.5.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.5.1 and 6.5.2 (Table 6.8).

In 2004, the proposed hydro operations are expected to result in less survival of the single major population group of UCR spring chinook salmon (Tables 6.6 and 6.8), a Medium negative effect compared with the reference operation. Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have a Low positive effect, as described in Section 6.5.2.4, and tributary habitat improvements described in Section 6.5.2.2 are expected to result in a Very Low positive effect. Because the positive effects are less than those of the proposed hydro operation, the net effect of the proposed action would be lower survival, and therefore a net reduction in the numbers and reproduction of this ESU compared with the reference operation.

By 2010, the Action Agencies' propose to complete structures that will improve fish passage at mainstem FCRPS dams, resulting in an improvement in survival compared to the reference operation. In addition to the fish predator reduction program and the tributary habitat actions, the Action Agencies propose to implement the preferred alternative developed in the Record of Decision for Caspian tern management reduction, which is expected to result in a Low relative change, as described in Section 6.5.2. The combination of expected improvements indicates that by 2010 it is likely that there would be an improvement in the numbers, reproduction, and possibly distribution of this ESU as a result of the proposed action, as compared with the reference operation.

6.6 UPPER WILLAMETTE CHINOOK SALMON

6.6.1 Effect of Proposed Hydro Operations

6.6.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

The proposed action is expected to have little or no effect on yearling migrant UWR chinook salmon, compared to the reference operation, because spring flows and water quality are nearly identical in the two operations and this ESU does not pass any FCRPS projects. The (unknown) proportion of UWR chinook that migrate as subyearlings may reach the estuary during summer months, when proposed flows are lower than in the reference operation and some reduction in shallow-water rearing habitat is likely.

UWR spring chinook display predominantly a stream-type life history strategy like that of SR spring/summer chinook salmon, but some emigrants are subyearlings and thus presumably ocean-type fish. Proposed hydro operations are expected to have only a minor effect on the quantity and quality of juvenile migration and rearing habitat in the Columbia River estuary and plume during the spring, when yearling UWR spring chinook salmon are in these areas. Habitat effects in the estuary are essentially the same as those described for SR spring/summer chinook salmon in Section 6.3. Those UWR chinook that exhibit an ocean-type life history strategy probably make use of shallow-water habitat in the upper tidally influenced and lower estuary and then expand into deeper water habitat as they mature (Fresh *et al.* 2004). UWR chinook that migrate as subyearlings are dependent upon shallow-water rearing areas (Fresh *et al.* 2004). To the extent that UWR chinook rear in the estuary during the summer, when proposed flows are significantly lower than reference operation flows, their habitat will be reduced. The difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem, compared to the reference operation, will be proportional to this effect. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of UWR chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.6.1.2 Qualitative Characterization of All Effects of Proposed Hydro Operations

Qualitatively, NOAA Fisheries concludes that the proposed action is likely to reduce abundance and productivity of UWR chinook salmon by a Very Low amount for all populations and major population groups.

6.6.2 Effect of Non-hydro Measures

6.6.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.6.2.1.1 Enhance and Restore Estuarine Habitat. UWR spring chinook display predominantly a stream-type life history strategy like that of SR spring/summer chinook salmon, but some emigrants are subyearlings and thus presumably ocean-type fish. Considering the magnitude, extent, and distribution of the proposed estuary actions, they are expected to provide 0 short-term and 0 long-term (by 2014) benefits to stream-type juvenile migrants. Those UWR chinook that exhibit an ocean-type life history strategy probably make use of shallow-water habitat in the upper tidally-influenced and lower estuary and then expand into deeper water habitat as they mature (Fresh *et al.* 2004). NOAA Fisheries concludes that the magnitude, extent, and distribution of the proposed estuary actions would also provide 0 short-term and Medium (very Low end of range) long-term (by 2014) benefits to ocean-type migrants from this ESU. These levels of benefit will accrue to all populations in the single major population group.

6.6.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary and the resulting expected level of benefit (0 short-term; Low long-term [by 2014]), which can be applied to both yearling and subyearling UWR chinook migrants, are described in Section 6.3.2.1.2. These levels of benefit will accrue to all of the populations in the single major population group. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.6.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies do not propose any non-hydro offsets in the tributaries affecting Upper Willamette River chinook. NOAA Fisheries concludes no benefit to population or ESU viability from tributary non-hydro offsets for this ESU.

6.6.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing to complete the HGMP planning process designed to identify hatchery improvements and reforms which could affect UWR chinook salmon. However, development of the plan itself will have no direct effect on the viability of this ESU.

6.6.3 Net Effect of Hydro and Non-hydro Actions

6.6.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.3.1 and 6.3.2 (Table 6.11).

The proposed hydro operations are expected to result in a Very Low effect (i.e., close to zero) on survival of UWR chinook through the estuary compared to that of the reference operation. By 2010, it is likely that the proposed reduction in Caspian tern predation would have Low positive effects on the survival of UWR chinook salmon. Additionally, by 2010, estuary habitat actions are expected to result in Medium improvements for the subyearling component of this ESU. In summary, it is likely that there would be no net difference between 2004 and 2009 and an improvement in numbers, reproduction, or distribution of this ESU between 2010 and 2014 as a result of the proposed action when compared with the reference operation.

6.7 LOWER COLUMBIA RIVER CHINOOK SALMON

6.7.1 Effect of Proposed Hydro Operations

6.7.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

Juvenile LCR chinook salmon migrate as both yearlings and subyearlings, depending upon population. Similarly, adults return to spawn in both the spring and fall.

For spring-run populations with yearling juvenile migrants, the primary mainstem and estuary habitat differences between the proposed hydro operations and the reference operation are expected to be minor, as described in Section 6.3 for SR spring/summer chinook salmon.

Most LCR chinook populations are fall-run, with subyearling juveniles that migrate during the spring and summer. The primary mainstem, estuary, and plume habitat differences between the proposed hydro operations and the reference operation are expected to be similar to those described in Section 6.2 for SR fall chinook salmon. Like SR fall chinook, LCR chinook are dependent upon shallow-water rearing areas (Fresh *et al.* 2004). To the extent that LCR chinook rear in the estuary during the summer when proposed flows are significantly lower than reference operation flows, their habitat will be reduced.

6.7.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival.

6.7.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration. Most populations of LCR chinook salmon originate below Bonneville Dam and do not migrate past FCRPS hydro projects. However, two populations (Hood River and Upper Gorge) that are in two of the six major population groups (Gorge Fall-Run and Gorge Spring-Run) migrate through Bonneville pool and dam.

Modeling results indicate relative differences in survival between the 2004 proposed hydro operations and the reference operation for the single population of yearling-type LCR chinook salmon that migrates past Bonneville Dam averaging -1.6%, ranging from -0.6% to -1.9% (Table 6.8; Appendix D).

No quantitative estimates are available to determine the effect of proposed 2004 hydro operations on survival of the three populations of juvenile LCR chinook salmon that migrate past Bonneville Dam as subyearlings. Survival rates would likely be no higher than that of SR fall chinook salmon, which are subyearlings that migrate past Bonneville Dam at a larger size. Therefore, modeling results indicate a minimum 2.7% (0.2% to 4.4%) reduction in survival is likely (Table 6.8; Appendix D).

No difference in adult survival through Bonneville Dam and pool is expected between the proposed hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gaps for yearling and subyearling chinook, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.7.1.2.2 Effect of Proposed Hydro Operations and 2010 System Configuration Improvements. Modeling results indicate that the relative differences in survival between the intermediate-term proposed hydro improvements and operations and the reference operation for the single population of yearling-type LCR chinook salmon that migrates past Bonneville Dam indicate that the average reduction in survival of 1.4%, ranging from 0.5% to 1.9%, is a slight improvement but nearly unchanged from the 2004 analysis (Table 6.9; Appendix D).

For the three populations of juvenile LCR chinook salmon that migrate past Bonneville Dam as subyearlings, modeling results for the proposed 2010 hydro improvements and operations show that the relative reduction in survival (2.6%, with a range from 0.1- 4.3%) would be nearly unchanged from the 2004 analysis (Table 6.9; Appendix D).

No reduction in adult survival is expected as a result of the proposed 2010 hydro operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gaps for yearling and subyearling chinook, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.7.1.2.3 Effect of Proposed Hydro Operations and 2014 System Configuration Improvements. Modeling results indicate that the relative differences in survival between the long-term proposed hydro improvements and operations and the reference operation for the single population of yearling-type LCR chinook salmon that migrates past Bonneville Dam drops to an average reduction of 0.8%, ranging from a relative survival reduction of 1.8% to a relative survival improvement of 1.0% (Table 6.10; Appendix D).

For the three populations of juvenile LCR chinook salmon that migrate past Bonneville Dam as subyearlings, modeling results for the long-term proposed hydro improvements and operations show that the reduction in survival (2.6%, with a range from 0.1- 4.3%) would be nearly unchanged from the 2004 and 2010 analyses (Table 6.10; Appendix D).

No reduction in adult survival is expected as a result of the proposed 2014 hydro operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gaps for yearling and subyearling chinook, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR chinook salmon is largely inferential, as discussed in Section 5.2.3.

6.7.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative “habitat approach” and the quantitative “survival approach” leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of LCR chinook salmon by a Medium amount for the Gorge Fall MPG, by a Low amount for the Gorge Spring MPG, and by a Very Low amount for the remaining four MPGs. Because of the differential effect on various populations, the proposed operation also is likely to reduce distribution and diversity of the ESU.

6.7.2 Effect of Non-hydro Measures

6.7.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.7.2.1.1 Enhance and Restore Estuarine Habitat. LCR chinook salmon display both stream- and ocean-type life histories (Fresh *et al.* 2004). Benefits of the proposed estuary actions are expected to be similar to those discussed for stream- and ocean-type migrants from the UWR chinook ESU (Section 6.6.2.1.1), 0 short-term and 0 long-term (by 2014) benefits for the stream-type life history strategy and 0 short-term and Medium (Very Low end of range) long-term for the subyearling life-history strategy. These levels of benefit will accrue to all of the populations in all of the major population groups.

6.7.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary and the resulting expected level of benefit (0 short-term; Low long-term [by 2014]), which can be applied to both yearling and subyearling LCR chinook salmon migrants, are described in Section 6.3.2.1.2. These levels of benefit will accrue to all of the populations in all of the major population groups. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, compensatory mortality would need to exceed approximately 50% to reduce the contribution of offsetting actions towards filling the hydrosystem survival gap below that estimated by the Action Agencies in their BA. NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.7.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies do not propose any non-hydro offsets in the tributaries affecting Lower Columbia River chinook. NOAA Fisheries concludes no benefit to population or ESU viability from tributary non-hydro offsets for this ESU.

6.7.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing to complete the HGMP planning process designed to identify hatchery improvements and reforms which could affect LCR chinook salmon. However, development of the plan itself will have no direct effect on the viability of this ESU.

6.7.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

6.7.3 Net Effect of Hydro and Non-hydro Actions

6.7.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.3.1 and 6.3.2 (Table 6.11). The proposed action affects major population groups that originate at different locations differentially.

6.7.3.1.1 Cascade Spring-Run MPG. This major population group originates below Bonneville Dam and rears primarily in streams, so there is a Very Low negative effect of the proposed action on this MPG compared with the reference operation. A reduction in Caspian tern predation in 2010-2014 is expected to result in a Low to Medium improvement, depending on assumptions regarding compensation. Therefore, it is likely that there would be no net difference, and over time an improvement, in the numbers, reproduction, and possibly distribution of this MPG as a result of the proposed action, compared with the reference operation.

6.7.3.1.2 Cascade Fall-Run, Cascade Late Fall-Run, and Coast Fall-Run MPGs. These three major population groups originate below Bonneville Dam and use the estuary for rearing. There is an unquantifiable Very Low difference between the proposed action and the reference operation on this MPG due to lower flows and slightly less rearing habitat under the proposed action, relative to the reference operation. Habitat restoration projects in the estuary below the confluence with the Willamette River are expected to result in a Medium improvement by 2010, and the reduction in Caspian tern predation by 2010 is expected to result in Low improvements for this MPG. Therefore, it is likely that there would be no net difference and, over time, an improvement in the numbers, reproduction, and possibly distribution of this MPG as a result of the proposed action, compared with the reference operation.

6.7.3.1.3 Gorge Spring-Run MPG. This major population group originates upstream of Bonneville Dam and migrates through Bonneville pool and dam. There is likely to be a Low negative difference between the proposed operation and the reference operation due to lower reduced passage survival through the Bonneville project. Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have an immediate Low positive effect for this MPG, but this is unlikely to be of sufficient magnitude to offset the hydro operation effects. A reduction in avian predation by 2010 is expected to result in a Low to Medium improvement, depending upon assumptions about compensation. Therefore, it is likely that in the short term, there would be reduction, but in the long term, no net difference and possibly an improvement in the numbers, reproduction, or distribution of this MPG as a result of the proposed action, compared with the reference operation.

6.7.3.1.4 Gorge Fall MPG. This major population group originates upstream of Bonneville Dam migrates through Bonneville pool and dam and uses the estuary for rearing. There is likely to be a Low survival reduction, compared to the reference operation, due to lower passage survival through the Bonneville project, as well as a negative effect of lower estuary flow and slightly less shallow-water rearing habitat compared with the reference operation. Combined, a Medium negative effect of the proposed hydro operation is expected. Continuation and expansion of the

Northern Pikeminnow Management Program is estimated to have an immediate Low positive effect for this MPG, but this is unlikely to be of sufficient magnitude to offset the hydro operation effects. Habitat restoration projects in the estuary below the confluence with the Willamette River are expected to result in a Medium improvement by 2010. The reduction in avian predation is expected to result in a Low level of improvements for this MPG by 2010. Therefore, it is likely that there would be a short-term reduction, but in the long term, there would be no net difference and possibly an improvement in the numbers, reproduction, or distribution of this MPG as a result of the proposed action compared with the reference operation.

6.7.3.1.5 Summary. Because the numbers and reproduction of two major population groups are expected to be lower during the initial years of this proposed action than with the reference operation, it is expected that the ESU as a whole would be lower. However, for each MPG, there is no difference in the long-term effects and possibly an improvement. Accordingly, in the long term (2010-2014) it is expected that the ESU as a whole would be unaffected or perhaps improved.

6.8 SNAKE RIVER STEELHEAD

6.8.1 Effect of Proposed Hydro Operations

6.8.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

Effects of the proposed action on habitat function are expected to be very similar to those described for SR spring/summer chinook salmon in Section 6.3. These effects are minor, except for safe passage past barriers, which is impaired due to lower spill levels provided under the proposed hydro operations.

6.8.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival

6.8.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration.
<u>Effect of transport operations on SR steelhead</u>. Compared to recent operations, the Action Agencies' proposed action for transport operations for SR steelhead delays the date when fish are collected and transported until April 20 in most water conditions. Prior to that date, spill will be provided at Snake River collector projects and all fish collected would be returned to the river. In the lowest 15% of runoff conditions, when seasonal average flows in the Snake River are forecasted to be less than 70 kcfs, no spill is provided in the proposed action at Snake River collector projects and all fish collected are transported. The Action Agencies have not proposed collection and transportation of SR steelhead at McNary Dam. These changes are consistent with current research information that indicates there is not a consistent benefit provided from transportation during the month of April for wild juvenile SR steelhead. However, only several years of data are available on this issue at this time. Williams *et al*. (2004) noted that, sometimes survival for hatchery and wild steelhead transported to below Bonneville Dam as a juvenile to

return as an adult is lower than the adult return rate for in-river migrants, but at other times higher. Hatchery steelhead, however, have shown a survival benefit from transport operations.

Balancing the potential survival benefits of transportation with the possible risks that this operation poses to long-term diversity of the ESU is challenging. Providing both spill and transportation is a method to balance the degree transportation is used as a management tool. Spill reduces the percentage of fish transported and increases the survival of the fish migrating in-river. The reference operation provided spill through the month of April in those years when the average seasonal flow at Lower Granite Dam was projected to be between 70 to 85 kcfs, and terminated spill on May 1 during these relatively low runoff years. The proposed action transport operation calls for no spill and a maximum transportation operation when the seasonal average flow in the Snake River is projected to be less than 70 kcfs, which is a reduced flow threshold from the 85 kcfs average flow level identified in the 2000 Biological Opinion.

The 70 kcfs flow threshold was chosen to reflect a breakpoint where in-river survival appears to decrease for spring chinook juvenile migrants. This breakpoint for juvenile steelhead was estimated to be 79 kcfs (Williams *et al*. 2004). This breakpoint also appears to be associated with increasing water temperatures, which usually occur during the month of May. Due to the high guidance efficiency of SR steelhead at collector projects, the percentage of steelhead collected will generally be quite high. Thus both the reference and proposed operations call for decreasing the percentage of fish transported during the early spring, since that operation has not been demonstrated to provide a consistent survival benefit.

Modeling results indicate that proposed hydro operations and 2004 system configuration would result in a lower relative survival of juvenile SR steelhead that remain in-river through the Lower Granite to Bonneville reach, compared to the reference operation, by an average of 10.5%, with a range of -1.6% to -30.6% (Table 6.8; Appendix D). Because a large proportion, ranging from approximately 60-90%, of juvenile SR steelhead migrants are collected and transported past FCRPS dams, there is a much smaller relative reduction in system survival (on average, 1.3% [ranging from a 3.3% reduction to a 0.4% improvement]), which includes direct survival and differential post-Bonneville survival (D) of transported fish. The range of system survival estimates indicates that the proposed hydro operation would have slightly more impacts in some years, but could also result in minor survival improvements in others. The mortality associated with proposed hydro operations is expected to affect all populations of Snake River spring/summer chinook salmon equally, and that mortality is expected to begin immediately.

No difference in adult survival is expected between the proposed hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gaps for juvenile steelhead, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR steelhead is largely inferential, as discussed in Section 5.2.3.

6.8.1.2.2 Effect of Proposed Hydro Operations and 2010 System Configuration Improvements. For this ESU, with expected 2010 intermediate-term system configuration improvements, the relative system survival difference between the proposed hydro operation and the reference operation decreased from the 2004 gap analysis and resulted in an reduction of 0.1% (ranging from a 3.1% reduction to a 1.8% survival improvement). The relative difference in in-river survival rates decreased to -3.4%, ranging from about -26% to +7%) (Table 6.9; Appendix D). This large reduction in the 2010 survival gap compared to the 2004 gap is due to the installation and operation of RSWs at Lower Monumental and McNary dams, which results in more juvenile fish remaining in the river due to increased spill efficiencies at these projects in the 2010 proposed hydro operation, thus increasing the in-river survival rates with other planned survival improvements, including various improvements in spillway, turbine and bypass survivals at various mainstem FCRPS dams. Note that system configuration parameter changes assumed for SR steelhead for the 2010 proposed hydro operation are similar to those of SR spring chinook, as identified above in Section 6.3.1.2.2.

No difference in adult survival is expected between the proposed 2010 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gaps for juvenile steelhead, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR steelhead is largely inferential, as discussed in Section 5.2.3.

6.8.1.2.3 Effect of Proposed Hydro Operations and 2014 System Configuration Improvements. For this ESU, with expected long-term system configuration improvements, the relative system survival difference between the proposed hydro operation and the reference operation remained unchanged from the 2010 gap analysis, with a survival reduction of 0.1% (ranging from a 3.1% reduction to a 2.2% survival improvement). However, the relative difference in in-river survival rates, compared to the reference operation, decreased to -1.3% (ranging from -25% to a survival improvement of 5.5%) (Table 6.10; Appendix D). This additional reduction in the 2014 survival gap compared to the 2010 gap is due to the installation and operation of RSWs at Little Goose, Lower Monumental, McNary and John Day dams, which results in more juvenile fish remaining in the river due to increased spill efficiencies at these projects in the 2014 proposed hydro operation, thus increasing the in-river survival rates with the other planned survival improvements, including various improvements in spillway, turbine and bypass survivals at most mainstem FCRPS dams. Note that system configuration parameter changes assumed for SR steelhead for the 2014 proposed hydro operation are similar to those of SR spring chinook, identified in Section 6.3.1.2.3 above.

No difference in adult survival is expected between the proposed 2014 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). In 2014, the difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative system-survival gaps for juvenile steelhead, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR steelhead salmon is largely inferential, as discussed in Section 5.2.3.

6.8.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative "habitat approach" and the quantitative "survival approach" leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of Snake River steelhead by a Low amount for all populations and major population groups. It is not likely that the proposed action would reduce distribution or diversity of the ESU.

6.8.2 Effect of Non-hydro Measures

6.8.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.8.2.1.1 Enhance and Restore Estuarine Habitat. Like SR spring/summer chinook salmon, SR steelhead display a stream-type life history strategy (Fresh *et al.* 2004). As described in section 6.3.2.1.1, the magnitude, extent, and distribution of the proposed estuary actions are expected to provide 0 benefit to yearling migrants (in the case of SR steelhead, this level of benefit would apply to all the populations and major population groups). The full benefit to be derived from these projects will accrue over the term of the Biological Opinion. Thus, the proposed action for estuary habitat restoration will provide 0 short-term and 0 long-term benefits to the SR steelhead ESU. This level of benefit will accrue to all of the populations in all of the major population groups.

6.8.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. Based on the projected levels of tern colony size resulting from implementation of alternatives C and D of the draft EIS, NOAA Fisheries estimates level of benefit for SR steelhead as approximately 0 short-term and Medium long-term (by 2014) benefits (i.e., a 6.6% relative increase in survival). This level of benefit will accrue to all of the populations in all of the major population groups. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, compensatory mortality would need to exceed approximately 75% to reduce the contribution of offsetting actions towards filling the hydrosystem survival gap below that estimated by the Action Agencies in their BA. NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.8.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

USBR's conservation actions implemented since 2000 and proposed conservation measures, discussed in Section 6.3.2.2, would provide Very Low short-term and Very Low long-term benefits to a small portion of the Snake River steelhead ESU (i.e., populations in the Lemhi, Upper Salmon, and Little Salmon subbasins).

The Action Agencies' 2003 Progress Report identified habitat improvement actions that they had implemented under the 2000 RPA for the purpose of offsetting adverse hydropower impacts through at least 2010. Some of those actions were implemented in this subbasin. The Action Agencies will ensure these that actions are maintained so that benefits continue over the term of the UPA. Additional details, including metrics that describe the benefits of each action are provided in the UPA. NOAA Fisheries expects that some positive but currently immeasurable level of survival improvement, in addition to that derived from the conservation actions and measures detailed in the UPA, will accrue from each of these actions but has not attempted to quantify that benefit for the purpose of this analysis.

6.8.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing to complete the HGMP planning process designed to identify hatchery improvements and reforms which could affect UCR spring chinook salmon. However, development of the plan itself will have no direct effect on the viability of this ESU.

6.8.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

6.8.3 Net Effect of Hydro and Non-hydro Actions

6.8.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.8.1 and 6.8.2 (Table 6.11).

In 2004, the proposed hydro operations are expected to result in lower survival of all major population groups of SR steelhead by a Low negative effect compared with the reference operation. Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have a Low positive effect, as described in Section 6.3.2.4, but this is unlikely to be of a magnitude sufficient to offset the hydro operation impacts. By 2010, the Action Agencies' propose to complete structures that will improve fish passage at mainstem FCRPS dams, so survival with the proposed action is expected to be nearly equal to that associated with the reference operation. In addition to the fish predation reduction program, the Action Agencies propose to implement the preferred alternative for Caspian tern management by 2010, which is also expected to result in a Medium survival improvement for all major population groups. Tributary habitat improvement projects are expected to have a Very Low benefit for a few populations in this ESU. The combination of these effects is likely to result in no net change in the short-term and a likely improvement in the numbers, reproduction, and distribution of this ESU by 2010 as a result of the proposed action, compared with the reference operation.

6.9 Upper Columbia River Steelhead

6.9.1 Effect of Proposed Hydro Operations

6.9.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

As described in Section 6.2, proposed hydro operations are expected to have only a minor effect on habitat function with respect to water quantity, water velocity, and water quality during the spring period when juvenile and adult UCR steelhead migrate through the action area. The proposed operation does reduce the functioning of juvenile migration habitat with respect to safe passage past barriers by reducing spill levels from those in the reference operation. The magnitude of this habitat modification is significant, as reflected in results of quantitative modeling of in-river survival, which are described below.

Proposed hydro operations are expected to have only a minor effect on the quantity and quality of juvenile migration and rearing habitat in the Columbia River estuary and plume during the spring, when UCR spring chinook salmon are in these areas. Habitat effects in the estuary are essentially the same as those described for SR spring/summer chinook salmon in Section 6.3.

6.9.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival.

6.9.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration. Modeling results indicate that proposed hydro operations with 2004 system configuration is estimated to reduce the relative survival of juvenile UCR steelhead migrating between McNary Dam and Bonneville Dam, compared to the reference operation, by an average of 9.1%, with a range of reductions from 1.5% to 22.4% (Table 6.8; Appendix D). The mortality associated with the proposed 2004 hydro operations is expected to affect all populations of UCR steelhead equally, and that mortality is expected to begin immediately.

No difference in adult survival is expected between the proposed 2004 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is that there is expected to be some difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative system-survival gap for 2004, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of UCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.9.1.2.2 Effect of Proposed Hydro Operations and 2010 System Configuration. For UCR steelhead, the relative difference in the in-river survival rate of -2.9% (ranging from a reduction of 17.2% to a survival improvement of +5.1%) for the intermediate-term proposed hydro improvements and operation, when compared to the reference operation, decreased by an average of nearly two-thirds from the 2004 survival gap (Table 6.9; Appendix D). The substantial reduction in the relative in-river survival gap for UCR steelhead in the 2010 analysis is due to system configuration improvements such as installation of two RSWs at McNary Dam and various other fish passage survival improvements made at several lower Columbia River dams to increase spillway, turbine and bypass survivals, as described in Section 6.3.1.2.2 for SR spring/summer chinook salmon.

No difference in adult survival is expected between the proposed 2010 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem, compared to the reference operation, will be proportional to the relative system-survival gap, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of UCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.9.1.2.3 Effect of Proposed Hydro Operations and 2014 System Configuration. For UCR steelhead, the average relative difference in the in-river survival rate of -1.5% (ranging from a reduction of 16.6% to an improvement of nearly 8%) for the long-term proposed system configuration improvements and hydro operation, when compared to the reference operation, decreased by about one-half from the 2010 survival gap (Table 6.10; Appendix D). The substantial reduction in the relative in-river survival gap for UCR steelhead in the long term is due to system configuration improvements such as installation of surface bypasses at both McNary and John Day dams and various other fish passage survival improvements made at all four lower Columbia River dams to increase spillway, turbine and bypass survivals, as described in Section 6.3.1.2.3 for SR spring/summer chinook salmon.

No difference in adult survival is expected between the proposed 2014 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative system-survival gap for 2014, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of UCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.9.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative "habitat approach" and the quantitative "survival approach" leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of UCR steelhead by a Medium amount for all populations and the single major population group. It is not likely that the proposed action would reduce distribution or diversity of the ESU.

6.9.2 Effect of Non-hydro Measures

6.9.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.9.2.1.1 Enhance and Restore Estuarine Habitat. Like SR spring/summer chinook salmon, UCR steelhead display a stream-type life history strategy (Fresh *et al.* 2004). As described in section 6.3.2.1.1, the magnitude, extent, and distribution of the proposed estuary actions are expected to provide 0 benefit to yearling migrants (in the case of UCR steelhead, this level of benefit would apply to all the populations and the single major population group). The full benefit to be derived from these six projects will accrue over the term of the Biological Opinion. Thus, the proposed action for estuary habitat restoration will provide 0 short-term and 0 long-term (by 2014) benefits to UCR steelhead. This level of benefit will accrue to all of the populations in the single major population group.

6.9.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. Based on the projected levels of tern colony size resulting from implementation of alternatives C and D of the draft EIS, NOAA Fisheries estimates 0 short-term and Medium long-term (by 2014) benefits (i.e., a 15% relative increase in survival) to UCR steelhead. This level of benefit will accrue to all of the populations in the single major population group. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, compensatory mortality would need to exceed approximately 75% to reduce the contribution of offsetting actions towards filling the hydrosystem survival gap below that estimated by the Action Agencies in their BA. NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.9.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies have proposed a tributary habitat program on non-Federal lands in the lower reaches of the systems which they feel will improve overall survival for the ESU during its spawning and rearing life stages. Upper Columbia steelhead spawn and rear in tributaries to the upper Columbia River below Chief Joseph Dam. These tributaries include populations of the ESU in the Wenatchee, Entiat, Methow, and the Okanogan. Actions to improve spawning and rearing habitat in three of these tributaries (or subbasins) are included in the proposed action.

Actions to improve spawning and rearing habitat in the Okanogan are included as a BPA conservation measure in the UPA. The UPA states that this conservation measure is intended to meet a greater increment of overall survival for Upper Columbia steelhead during their spawning and rearing life stages than is required to avoid jeopardy to the species; consequently, it is formulated to partially meet recovery standards for this ESU as defined by the regulatory guidance in the Endangered Species Consultation Handbook (USFWS and NOAA Fisheries, p. 4-19).

The habitat program in the Wenatchee, Entiat, and Methow will include projects that address the limiting factors including fish entrainment, instream flow deficiencies, compromised channel morphology, and riparian condition. The Action Agencies state that these limiting factors will be addressed in the following manner (Table 6.13). Fish entrainment at screens may be addressed through adding new screens, modifying existing screens to meet current criteria, or eliminating the diversion through replacement wells or other means. Instream flow projects include lease or purchase of streamflow, water conservation projects which yield actual “wet water” instream which may be secured through state water law. Not counted in this metric are gaging stations or other water measurement initiatives or investigations that may be necessary to support the evaluation and protection of instream flows for fish. Channel morphology projects include access projects which provide fish passage at structures or conditions that create migration barriers including diversion dams, culverts, low-flow channels, etc. Stream complexity restoration projects include side channel connectivity, floodplain connectivity, channel reconfiguration, large woody debris placement, etc. Riparian protection projects include acquisition of riparian easements or purchases. Riparian enhancement projects include streambank stabilization and riparian treatments such as fencing or reconstruction. Conservation measures for the Okanogan will be focused on possible riparian improvements and instream flow transactions to benefit the ESU.

Table 6.13. Proposed Action, Upper Columbia Steelhead, Wenatchee, Entiat, and Methow Subbasin (from Updated Proposed Action, 30 August 2004).

Limiting Factor	Metric Measurement	Metric Goal in three years	Cumulative Metric Goal in six years
Entrainment	a. Number of screens addressed	5	10
Instream flow projects	a. Cubic Feet per Second (cfs) of water protected for instream flows	12 cfs	40 cfs
Channel Morphology	a. Miles of access restored b. Miles complexity restored	60 miles 5 miles	105 miles 10 miles
Riparian Protection Enhancement	a. Number of miles protected b. Number of miles enhanced.	4 miles 6 miles	12 miles 12 miles

The limiting factors identified for Upper Columbia steelhead in each of the subbasins are similar to those identified for the Upper Columbia spring chinook. The Action Agencies considered those similarities and selected an identical suite of habitat improvements for both ESUs in each subbasin. The Action Agencies state that, although steelhead tend to utilize habitat higher in the river systems than chinook, much of those high spawning and rearing streams are located on lands administered by the U.S. Forest Service, which is formulating its own programs to improve habitat. To avoid duplication of efforts, the Action Agencies are focusing on habitat improvement programs for the four selected limiting factors that are lower in the subbasin systems and that will improve survival for both ESUs. Therefore, the proposed action metrics goals are identical for both species.

This program is explained more fully in Section III. D. 4 of the Updated Proposed Action. Summarizing that section, the Action Agencies propose to address the following limiting factors across the subbasins listed:

> ***Wenatchee***: The Action Agencies will focus on projects which address changes in channel morphology which includes floodplain connectivity, entrainment, and riparian enhancement.
>
> ***Entiat***: The Action Agencies will focus on projects which address changes in channel morphology in the lower river to include improvements to stream complexity and channel connectivity. The Action Agencies state that other channel morphology improvements are anticipated in other reaches of the subbasin.
>
> ***Methow***: The Action Agencies will primarily focus on projects which address changes in channel morphology with additional projects to effect limited improvements to instream flow. Some riparian protection and enhancement projects are also proposed.

Although the Action Agencies do not identify their commitments in the form of discrete projects across these subbasins they do provide specific commitments in the form of three- and six-year performance measures across these subbasins. The Action Agencies have adopted habitat metrics to increase the certainty and specificity of offsetting habitat improvements. The Action Agencies state that these habitat metrics will be used to increase their accountability for specific targets and further define the expected level of effort needed for ESU-specific survival improvement. The Action Agencies have developed an initial set of performance measures for tributary habitat improvements that are expressed as goals for changes in physical habitat conditions for targeted ESUs. Through an adaptive management loop grounded in a structured monitoring program the Action Agencies commit to a more sophisticated means to measure biological performance and the effectiveness of habitat actions (UPA page 13). The Action Agencies have committed to achieving the survival improvements intended by the UPA in three steps: 1) achieve interim metric goals which the Action Agencies believe will achieve the biological improvements, based on current science, 2) verify that expected survival improvements are achieved through implementation of a tributary RM&E program, and 3) revise the initial habitat performance metrics, as necessary, to ensure that the tributary program achieves the survival improvements intended by the UPA using information from the tributary RM&E program.

The Action Agencies state that, based on their analysis, the total proposed habitat improvements in the Wenatchee, Entiat, and Methow subbasins from achieving the habitat metric goals will fulfill the Medium habitat improvement potential. NOAA Fisheries cannot evaluate the Action Agencies' analyses leading to these conclusions since these are not included as part of the proposed action. NOAA Fisheries does not agree with the Action Agencies approach to arriving at non-hydro benefit (Appendix B, step 9, Updated Proposed Action, November 24, 2004).

In its qualitative analysis of the proposed action for the Upper Columbia River steelhead, NOAA Fisheries' evaluation included consideration of 1) the categories of actions identified in the cumulative performance metric goal commitments relative to the significant limiting factors identified for these populations in Appendix E, 2) the distribution and severity of limiting factors across the three populations comprised by this ESU, and 3) the Action Agencies commitments to ensure that the tributary program achieves the survival improvements intended by the UPA, as described above. NOAA Fisheries believes that, if the performance metrics are achieved by directing projects at the identified factors limiting Upper Columbia River steelhead, the aggregate benefit will address a Medium [low end of range] survival gap. NOAA Fisheries considered those tributary UCR steelhead projects implemented by the Action Agencies as identified in the PCTS since 2000 and, assuming an ongoing commitment of funds for O&M or RM&E, determined that they would provide a Very Low immediate benefit. Therefore, if the proposed metric goals are achieved at three and six years, NOAA Fisheries concludes that the proposed non-hydro offset program for Upper Columbia River steelhead that is capable of addressing a Medium [low end of range] survival gap will be in place by 2010. This conclusion relies on the Action Agencies commitments to ensuring that these metric goals will achieve the survival improvements intended by the UPA through the adaptive management process above.

NOAA Fisheries was not able to determine the magnitude of beneficial effects likely to result from the conservation measure proposed by BPA in the Okanogan, given the general description of the action. In considering the effect of this conservation measure, NOAA Fisheries assumed that restoration actions would be implemented in a manner consistent with BPA's Habitat Improvement Program Biological Opinion (June 2003). NOAA Fisheries therefore concludes that actions implemented in this manner will generally improve the condition of habitat and population at the local project level, even though the effect of this measure at the subbasin and population scale cannot be estimated.

The Action Agencies commit to implement a habitat effectiveness monitoring program in the Methow subbasin to confirm that the survival improvement goals are achieved. They expect this program to inform them about the survival effects of habitat improvement projects for this ESU. RM&E actions in the Updated Proposed Action will include an effects monitoring program for some of the projects implemented as part of the tributary proposed action. The Action Agencies commit to adapting the mix and locations to meet metric goals when subbasin and recovery plans, other peer-reviewed information, and RME results indicate that a different mix would be more beneficial to fish populations in the ESUs addressed in the tributary proposed action.

The Action Agencies' 2003 Progress Report identified habitat improvement actions that they had implemented under the 2000 RPA for the purpose of offsetting adverse hydropower impacts through at least 2010. Some of those actions were implemented in this subbasin. The Action Agencies will ensure these that actions are maintained so that benefits continue over the term of the UPA. Additional details, including metrics that describe the benefits of each action are provided in the UPA. NOAA Fisheries expects that some positive but currently immeasurable level of survival improvement, in addition to that derived from the conservation actions and measures detailed in the UPA, will accrue from each of these actions but has not attempted to quantify that benefit for the purpose of this analysis.

6.9.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing to complete the HGMP planning process designed to identify hatchery improvements and reforms which could affect UCR steelhead. However, development of the plan itself will have no direct effect on the viability of this ESU.

6.9.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

6.9.3 Net Effect of Hydro and Non-hydro Actions

6.9.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.9.1 and 6.9.2 (Table 6.11).

In 2004, proposed hydro operations are expected to reduce the survival of the single major population group of UCR steelhead, compared to the reference operation, by a Medium amount. Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have a Low positive effect, as described in Section 6.3.2.4. Because the positive fish predator reduction effect is less than the negative effects of proposed hydro operations, the net effect of the proposed action would be a net reduction in survival between 2004 and 2010, and therefore a net reduction in the abundance and productivity of this ESU.

By 2010, the Action Agencies' propose to complete structures that will improve fish passage at mainstem FCRPS dams, including RSWs at McNary Dam, thereby reducing the impact of proposed intermediate-term hydro operations by two-thirds. In addition to the fish predator reduction program, the Action Agencies propose to implement the preferred alternative for estuarine avian predation reduction, which is expected to result in a Medium relative change in Section 6.4.2. The Action Agencies also propose to implement habitat improvement projects that are likely to result in a Medium improvement. Therefore, the combination of expected improvements indicates that, by 2010, it is likely that there would be no net change and possibly an improvement in the abundance, productivity, or distribution of this ESU as a result of the proposed action.

6.10 MID-COLUMBIA RIVER STEELHEAD

6.10.1 Effect of Proposed Hydro Operations

6.10.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

The primary estuary and plume habitat changes associated with proposed hydro operations are expected to be very similar to those described in Section 6.3 for SR spring/summer chinook salmon.

6.10.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival

6.10.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration. MCR steelhead migrate through one, two, three, or four mainstem federal hydro projects in the lower Columbia River, depending upon the population. Modeling results indicate that the proposed hydro operations with 2004 system configuration would reduce the relative average survival of juvenile MCR populations from that of the reference operation by an average of 9.1%, with a range of reduction from 1.5% to 22.4%, for populations originating above McNary Dam; 7.7%, with a range of reduction from 1.3% to 18.7%, for populations migrating through the John Day reservoir to Bonneville Dam; 4.7%, with a range of reduction from 1.2% to 10%, for the John Day River populations originating between McNary and John Day dams; 3.8%, ranging from a reduction of 0.2% to 9.1%, for populations originating between The Dalles and John Day dams; and 2.8%, ranging from a reduction of 0.2% to 6.2%, for populations originating between Bonneville and The Dalles dams (Table 6.8; Appendix D). The mortality associated with proposed hydro operations is expected to affect all populations of MCR steelhead, and that mortality is expected to begin immediately.

No difference in adult survival is expected between the proposed 2004 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative system-survival gap for each population by 2004, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of MCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.10.1.2.2 Effect of Proposed Hydro Operations and 2010 System Configuration Improvements. Modeling results indicate that proposed intermediate-term system configuration improvements and hydro operations would lead to the following average relative differences in survival of the various juvenile MCR populations of steelhead, compared to that of the reference operation:

- For populations originating above McNary Dam, an average survival reduction of 2.9% (ranging from a 17.2% reduction to 5.1% survival improvement)

- For populations migrating through the John Day reservoir to Bonneville Dam; an average survival reduction of 4.5% (ranging from a 16.1% reduction to a 2.2% survival improvement)

- For the John Day River populations, which originate between McNary and John Day dams, an average survival reduction of 1.4% (ranging from a 7.1% reduction to a 2.4% survival improvement)

- For populations originating between The Dalles and John Day dams, an average survival reduction of 1.9% (ranging from a 7.5% reduction to a 1.5% survival improvement)

- For populations originating between Bonneville and The Dalles dams,– an average survival reduction of 2.4% (ranging from no reduction to a 6.0% reduction) (Table 6.9; Appendix D)

The substantial reduction in the relative in-river survival gap for most MCR steelhead stocks in the intermediate-term is due to system configuration improvements such as installation of two RSWs at McNary Dam and various other fish passage and survival improvements made at several lower Columbia River dams to increase spillway, turbine and bypass survivals, as described in Section 6.3.1.2.2 for SR spring/summer chinook.

No difference in adult survival is expected between the proposed 2010 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative system-survival gap for each population by 2010, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of MCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.10.1.2.3 Effect of Proposed Hydro Operations and 2014 System Configuration Improvements. Modeling results indicate that proposed long-term system configuration improvements and hydro operations would lead to the following average relative differences in survival of the various juvenile MCR populations of steelhead, compared to the reference operation:

- For populations originating above McNary Dam, an average survival reduction of 1.5% (ranging from a 16.6% reduction to 7.9% survival improvement)

- For populations migrating through the John Day reservoir to Bonneville Dam; an average survival reduction of 3.2% (ranging from a 15.4% reduction to a 5% survival improvement)

- For the John Day River populations, which originate between McNary and John Day dams, an average survival reduction of 0.1% (ranging from a 6.4% reduction to a 5.1% survival improvement)

- For populations originating between The Dalles and John Day dams, an average survival reduction of 0.8% (ranging from roughly a 7% reduction to nearly a 4% survival improvement)

- For populations originating between Bonneville and The Dalles dams, an average survival reduction of 1.8% (ranging from about a 6% reduction to a 1.6% survival improvement) (Table 6.10; Appendix D)

The substantial reduction in the relative in-river survival gap for most MCR steelhead stocks in the long term is due to system configuration improvements such as installation of surface bypasses at both McNary and John Day dams and various other fish passage survival improvements made at all four lower Columbia River dams to increase spillway, turbine and bypass survivals, as described in Section 6.3.1.2.3 for SR spring/summer chinook.

No difference in adult survival is expected between the proposed 2014 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative system-survival gap for each population by 2014, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of MCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.10.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative "habitat approach" and the quantitative "survival approach" leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of MCR steelhead by a Medium amount for all MPGs in 2004 and by a Low or Medium amount for each MPG by 2010 (Table 6.8). Because of the differential effect on various populations, the proposed operation also is likely to reduce distribution and diversity of the ESU.

6.10.2 Effect of Non-hydro Measures

6.10.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.10.2.1.1 Enhance and Restore Estuarine Habitat. Like SR spring/summer chinook salmon, MCR steelhead display a stream-type life history strategy (Fresh *et al.* 2004). As described in section 6.3.2.1.1, the magnitude, extent, and distribution of the proposed estuary actions are expected to provide 0 benefit to yearling migrants (in the case of MCR steelhead, this level of benefit would apply to all the populations and major population groups). The full benefit to be derived from these six projects will accrue over the term of the Biological Opinion. Thus, the proposed action for estuary habitat restoration will provide 0 short-term and a 0 long-term (by 2014) benefit to MCR steelhead. This level of benefit will accrue to all of the populations in all of the major population groups.

6.10.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. Based on the projected levels of tern colony size resulting from implementation of alternatives C and D of the draft EIS, NOAA Fisheries estimates 0 short-term and Medium long-term (by 2014) benefits (i.e., a >6% relative increase in survival) to MCR steelhead. This level of benefit will accrue to all of the populations in all of the major population groups. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, compensatory mortality would need to fall between 50% and 75% to reduce the contribution of offsetting actions towards filling the hydrosystem survival gap below that estimated by the Action Agencies in their BA. NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.10.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

NOAA Fisheries has identified 16 populations of the Mid-Columbia River ESU grouped into four major populations groups which spawn and rear in tributaries to the Columbia River ranging from the Klickitat River to the Yakima River. A distinctive characteristic of this ESU is that different populations must navigate different numbers of the FCRPS dams during upstream and downstream migrations. Populations may need to pass one to four dams, depending upon the location of their particular spawning and rearing tributaries. The Action Agencies' proposed tributary habitat conservation measures will focus on four of the 16 identified populations identified by NOAA Fisheries' Interior Columbia Basin Technical Recovery Team. These populations constitute one of the four major population groups in this ESU.

The Action Agencies propose a tributary habitat conservation measure on non-Federal lands which addresses those populations which fall within the Medium range of habitat improvement potential. The Action Agencies commit to focusing actions in lower reaches of these systems based on opportunities provided by private landowners. The tributary habitat improvement program for those populations which spawn in tributary streams which enter the Columbia River between McNary and John Day Dams (3 dam fish) will be addressed by USBR's conservation measure in three subbasins of the John Day River which improve habitat conditions for four populations. The John Day basin subbasins are the North Fork John Day, the Middle Fork John Day, and the Upper Mainstem John Day which includes the South Fork John Day.

This program will include projects which address the following limiting factors 1) fish entrainment, 2) instream flow deficiencies, and 3) compromised channel morphology. The USBR states that these limiting factors will be addressed in the following manner (Table 6.14). Fish entrainment at screens may be addressed through adding new screens, modifying existing screens to meet current criteria, or eliminating the diversion through replacement wells or other means. Instream flow projects include lease or purchase of streamflow, water conservation projects which yield actual "wet water" instream which may be secured through state water law. Not counted in this metric are gaging stations or other water measurement initiatives or investigations which may be necessary to support the evaluation and protection of instream flows for fish. Channel morphology projects include access projects which provide fish passage at structures or conditions that create migration barriers including diversion dams, culverts, low-flow channels, etc. Stream complexity restoration projects include side channel connectivity, flood plain connectivity, channel reconfiguration, large woody debris placement, etc.

This program is explained more fully in Section III. D. 4 of the Updated Proposed Action. Summarizing that section, the Action Agencies propose to address the following limiting factors across the subbasins listed:

> ***John Day***: For the North Fork John Day, Middle Fork, Upper Mainstem and South Fork John Day subbasins the Action Agencies translated NOAA Fisheries' description of anthropomorphic limiting factors into those which are considered to describe the habitat condition instead of "causative factors" in formulating the conservation measure. The Action Agencies also eliminated from consideration some of the "limiting factors"

provided by NOAA Fisheries (such as fire activity and forestry) where the Action Agencies have no existing authority to affect or influence local land use policy. The remaining "limiting factors" were translated into three factors which the Action Agencies can potentially influence by working with local willing landowners: streamflow, entrainment, and channel morphology.

Table 6.14. Proposed Conservation Measure, John Day Populations of Mid Columbia Steelhead, North Fork John Day, Middle Fork John Day, and Upper Mainstem John Day including the South Fork John Day Subbasins (from Updated Proposed Action, 30 August 2004).

Limiting Factor	Metric Measurement	Metric Goal in three years
Entrainment	a. Number of screens addressed	30
Instream flow projects	a. Cubic Feet per Second (cfs) of water protected for instream flows	7 cfs
Channel Morphology	a. Miles of access restored b. Miles complexity restored	24 miles 3 miles

USBR does not commit to implementing specific projects in these subbasins and therefore does not describe the associated planning, regulatory, or implementation processes. USBR does provide specific commitments in the form of three-year metric goals. These tables are excerpted below. Financial and other necessary resources will be available to meet the 3-year metric goals described above contingent upon continuing Congressional funding (Updated Proposed Action, 30 Aug. 2004, Appendix B).

USBR's tributary habitat conservation measure commits to addressing limiting factors identified in NOAA Fisheries' recent analysis of potential habitat improvement (Appendix E) across only the subbasins identified above based on opportunities verified by contacting local knowledgeable individuals and organizations, reviewing information made available by the Council's recently drafted subbasin plans, and consulting other state and local documents.

The Mid-Columbia River steelhead ESU is composed of 16 populations distributed across four major population groups. Therefore the distribution of projects across multiple major population groups is a complicating factor in the analysis of effect to the ESU. NOAA Fisheries is unable to determine the likely ultimate distribution of the achieved performance metrics across the targeted populations and major population groups within the ESU. NOAA Fisheries does not mean that the potential benefit of individual projects is insignificant at a local scale, but NOAA Fisheries cannot evaluate the overall benefit to the ESU based on the information provided.

The Action Agencies state that, based on their analysis, survival improvements can be anticipated from the conservation measure in the North Fork John Day, Middle Fork John Day, and Upper Mainstem John Day, including the South Fork John Day.

Because the USBR lacks authority to implement non-flow related projects, NOAA Fisheries cannot assume that these projects will occur. If these projects are implemented to achieve the metric goals NOAA Fisheries would expect the currently assessed benefits to MCR steelhead to increase commensurate with the effectiveness of the actions. NOAA Fisheries will evaluate the survival benefit of those actions based on information from implementation of the tributary RM&E commitments described in the UPA. NOAA Fisheries assumes that the technical assistance program described as the USBR's measures, along with on-going actions being implemented and documented in the Action Agencies ESA progress reports, will provide Very Low short-term and a Very Low long-term (by 2014) benefit to a small portion of the MCR steelhead ESU.

The Action Agencies commit to implement a habitat effectiveness monitoring program in the John Day subbasin to confirm that the survival improvement goals are achieved. They expect this program to inform them about the survival effects of habitat improvement projects for this ESU. RM&E actions in the Updated Proposed Action will include an effects monitoring program for some of the projects implemented as part of the tributary conservation measure. The Action Agencies commit to adapting the mix and locations to meet metric goals when subbasin and recovery plans, other peer-reviewed information, and RME results indicate that a different mix would be more beneficial to fish recovery in the ESUs addressed in the tributary conservation measure.

The Action Agencies' 2003 Progress Report identified habitat improvement actions that they had implemented under the 2000 RPA for the purpose of offsetting adverse hydropower impacts through at least 2010. Some of those actions were implemented in this subbasin. The Action Agencies will ensure these that actions are maintained so that benefits continue over the term of the UPA. Additional details, including metrics that describe the benefits of each action are provided in the UPA. NOAA Fisheries expects that some positive but currently immeasurable level of survival improvement, in addition to that derived from the conservation actions and measures detailed in the UPA, will accrue from each of these actions but has not attempted to quantify that benefit for the purpose of this analysis.

6.10.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing to continue to fund the Umatilla River Hatchery program. NOAA Fisheries does not agree with the Action Agencies description of this program as a safety-net, because the population is not severely depressed and declining, and there is a continuing plan to maintain this hatchery program. However, NOAA Fisheries believes this program has increased the total number of adults returning to the Umatilla River. Long-term effects of the hatchery program on natural-origin production remain unknown. The hatchery broodstock comes from all or nearly all natural-origin adults each year. NOAA Fisheries notes that BPA also funds a steelhead kelt reconditioning program in the Yakima River that may be enhancing the Yakima River populations. Collectively, these two artificial propagation actions are providing a Very Low level of benefit to the ESU.

6.10.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

6.10.3 Net Effect of Hydro and Non-hydro Actions

6.10.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.10.1 and 6.10.2 (Table 6.11).

In 2004, the proposed hydro operations are expected to result in lower survival of all major population groups, a Medium negative effect compared with the reference operation. Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have a Low positive effect for all major population groups, as described in Section 6.10.2.4. For the John Day MPG and one population of the Walla Walla/Umatilla MPG, a Very Low improvement due to tributary habitat actions is expected. For all MPGs, the result would be a net reduction in survival between 2004 and 2010, and therefore a net reduction in the abundance and productivity of this ESU.

By 2010, the Action Agencies propose to complete structures that will improve fish passage at mainstem FCRPS dams, further reducing the impact of proposed long-term hydro operations. In addition to the fish predation reduction program and tributary habitat actions, the Action Agencies propose to implement the preferred alternative for Caspian tern management, which is expected to result in a Medium relative difference compared with the reference operation. The combination of expected improvements indicates that by 2010 it is likely that there would be no net change or possibly an increase in the numbers, reproduction, or distribution of each of the MPGs in this ESU as a result of the proposed action, compared with the reference operation.

6.11 UPPER WILLAMETTE STEELHEAD

6.11.1 Effect of Proposed Hydro Operations

6.11.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

UWR steelhead enter the Columbia River at its confluence with the Willamette River, so they do not migrate past any mainstem dams. The primary estuary and plume habitat changes associated with proposed hydro operations are expected to be very similar to those described in Section 6.3 for SR spring/summer chinook salmon. The difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem, compared to the reference operation, will be proportional to the relative system-survival gaps, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of UWR steelhead is largely inferential, as discussed in Section 5.2.3.

6.11.1.2 Qualitative Characterization of All Effects of Proposed Hydro Operations

Qualitatively, NOAA Fisheries concludes that the proposed action is likely to reduce abundance and productivity of UWR steelhead by a Very Low amount for all populations and major population groups. It is not likely that the proposed action would reduce distribution or diversity of the ESU.

6.11.2 Effect of Non-hydro Measures

6.11.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.11.2.1.1 Enhance and Restore Estuarine Habitat. Like SR spring/summer chinook salmon, UWR steelhead display a stream-type life history strategy (Fresh *et al.* 2004). As described in section 6.3.2.1.1, the magnitude, extent, and distribution of the proposed estuary actions are expected to provide 0 benefit to yearling migrants (in the case of UWR steelhead, this level of benefit would apply to all the populations in the major population group). The full benefit to be derived from these six projects will accrue over the term of the Biological Opinion. Thus, the proposed action for estuary habitat restoration will provide 0 short-term and a 0 long-term (by 2014) benefit to the UWR steelhead. This level of benefit will accrue to all of the populations in the single major population group.

6.11.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. Based on the projected levels of tern colony size resulting from implementation of alternatives C and D of the draft EIS, NOAA Fisheries estimates 0 short-term and Medium long-term (by 2014) benefit to UWR steelhead. This level of benefit will accrue to all of the populations in the single major population group. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, compensatory mortality would need to exceed 75% to reduce the contribution of offsetting actions towards filling the hydrosystem survival gap below that estimated by the Action Agencies in their BA. NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.11.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies do not propose any non-hydro offsets in the tributaries affecting Upper Willamette River steelhead. NOAA Fisheries concludes no benefit to population or ESU viability from tributary non-hydro offsets for this ESU.

6.11.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing to complete the HGMP planning process designed to identify hatchery improvements and reforms which could affect UWR steelhead. However, development of the plan itself will have no direct effect on the viability of this ESU.

6.11.3 Net Effect of Hydro and Non-hydro Actions

6.11.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.11.1 and 6.11.2 (Table 6.8).

The proposed hydro operations are expected to have a Very Low effect (i.e., close to zero) on survival of UWR steelhead through the estuary. It is likely that the proposed reduction in Caspian tern predation below the confluence of the Willamette River would have positive effects on the survival of UWR steelhead. In summary, it is likely that there would be no net difference, or possibly an improvement, in the numbers, reproduction, or distribution of this ESU between the proposed action and the reference operation.

6.12 LOWER COLUMBIA RIVER STEELHEAD

6.12.1 Effect of Proposed Hydro Operations

6.12.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

The primary estuary and plume habitat changes associated with proposed hydro operations are expected to be very similar to those described in Section 6.3 for SR spring/summer chinook salmon.

6.12.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival

6.12.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration. Most LCR steelhead originate below Bonneville Dam and do not migrate through any hydro projects. However, four populations in two major population groups migrate through Bonneville Dam and pool. Modeling results indicate that the proposed 2004 system configuration and hydro operations would reduce the survival of these four juvenile LCR steelhead populations, compared to the reference operation, an average of 2.8%, ranging from reductions of 0.2% to

6.2% (Table 6.8; Appendix D). The mortality associated with proposed hydro operations is expected to affect these four populations of LCR steelhead, and that mortality is expected to begin immediately.

No difference in adult survival through Bonneville Dam and pool between the proposed 2004 hydro operation and the reference operation is expected as a result of proposed hydro operations (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative 2004 system-survival gap for these four populations, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.12.1.2.2 Effect of Proposed Hydro Operations and 2010 System Configuration Improvements. Modeling results indicate that the proposed intermediate-term hydro improvements and operations would reduce the relative survival of these four juvenile LCR steelhead populations that migrate through Bonneville Dam and pool, when compared to the reference operation, by an average of 2.4%, ranging from no change in survival to a 6.0% reduction in survival (Table 6.9; Appendix D).

No difference in adult survival is expected between the proposed 2010 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). The difference is proportional to the relative 2010 system-survival gap for these four populations, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.12.1.2.3 Effect of Proposed Hydro Operations and 2014 System Configuration Improvements. Modeling results indicate that the proposed long-term hydro improvements and operations would reduce the relative survival of these four juvenile LCR steelhead populations that migrate through Bonneville Dam and pool, compared to the reference operation, by an average of 1.8%, ranging from a reduction of 6% to a survival improvement of 1.6% (Table 6.10; Appendix D). The reduction in the relative in-river survival gap for LCR steelhead in the long term is due to various fish passage improvements made at both Bonneville Dam powerhouses to increase bypass survivals, as described in Section 6.3.1.2.3 for SR spring/summer chinook salmon.

No difference in adult survival is expected between the proposed 2014 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). The difference is proportional to the relative system-survival gap for these four populations, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR steelhead is largely inferential, as discussed in Section 5.2.3.

6.12.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative "habitat approach" and the quantitative "survival approach" leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of LCR steelhead by a Medium amount for all populations originating upstream of Bonneville Dam and by a Very Low amount for all other populations. Because of the differential effect on various populations, the proposed operation also is likely to reduce distribution and diversity of the ESU.

6.12.2 Effect of Non-hydro Measures

6.12.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.12.2.1.1 Enhance and Restore Estuarine Habitat. Like SR spring/summer chinook salmon, LCR steelhead display a stream-type life history strategy (Fresh *et al.* 2004). As described in section 6.3.2.1.1, the magnitude, extent, and distribution of the proposed estuary actions are expected to provide 0 benefit to yearling migrants (in the case of LCR steelhead, this level of benefit would apply to all the populations and major population groups). The full benefit to be derived from these six projects will accrue over the term of the Biological Opinion. Thus, the proposed action for estuary habitat restoration will provide 0 short-term and 0 long-term (by 2014) benefits to LCR steelhead. This level of benefit will accrue to all of the populations in all of the major population groups.

6.12.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. Based on the projected levels of tern colony size resulting from implementation of alternatives C and D of the draft EIS, NOAA Fisheries estimates level of benefit for LCR steelhead as approximately 0 short-term and Medium long-term (by 2014) benefits (i.e., a 5% relative increase in survival) to LCR steelhead. This level of benefit will accrue to all of the populations in all of the major population groups. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, compensatory mortality would need to exceed 50% to reduce the contribution of offsetting actions towards filling the hydrosystem survival gap below that estimated by the Action Agencies in their BA. NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.12.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies do not propose any non-hydro offsets in the tributaries affecting Lower Columbia River steelhead. NOAA Fisheries concludes no benefit to population or ESU viability from tributary non-hydro offsets for this ESU.

6.12.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing to continue to fund the Hood River artificial propagation program. Evaluation to date shows that returning hatchery adults are about as productive as natural-origin adults. Long-term effects of the hatchery program on natural-origin production remains unknown. There is a robust research element to this program that should provide useful information on the effects of hatchery programs on natural production of steelhead over time. Numbers of adults returning to the Hood River are thought to have increased, but the benefit is believed to be very small, as this tributary represents only a small portion the ESU as a whole.

6.12.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

6.12.3 Net Effect of Hydro and Non-hydro Actions

6.12.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.12.1 and 6.12.2 (Table 6.11).

6.12.3.1.1 Cascade Summer-Run and Coastal Winter-Run MPGs. These major population groups originate below Bonneville Dam and rear primarily in streams, so there is a Very Low negative difference between the proposed action and the reference operation for these MPGs. The reduction in avian predation by 2010 is expected to result in a Medium improvement for this MPG. Therefore, it is likely that there would be no net difference and, over time, an improvement in the numbers, reproduction, and possibly distribution of these MPGs as a result of the proposed action.

6.12.3.1.2 Gorge Winter-Run and Gorge Summer-Run MPGs. Most populations in these major population groups originate upstream of Bonneville Dam and migrate through Bonneville pool and dam. There is likely to be a Medium negative difference due to lower passage survival through Bonneville. No difference in adult survival through Bonneville Dam and pool from the reference operation is expected as a result of proposed hydro operations (Appendix D). Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have an immediate Low positive effect for this MPG and ongoing hatchery programs are expected to have a Very Low effect. The reduction in avian predation by 2010 is expected to result in a Medium improvement for this MPG. Therefore, it is likely that there would be a reduction from 2004-2009 and no net difference and possibly an improvement by 2010 in the numbers, reproduction, or distribution of this MPG as a result of the proposed action.

6.13 COLUMBIA RIVER CHUM SALMON

6.13.1 Effect of Proposed Hydro Operations

6.13.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, including in the Estuary and Plume

Most populations of CR chum salmon originate below Bonneville Dam and do not migrate past hydro projects. However, if there is an extant Upper Gorge population (Section 4.3.11), some juveniles must migrate through Bonneville pool and dam. Juvenile migration through the lower river occurs during the spring, when proposed flows are very similar to those under the reference operation, so little or no effect on water quantity and velocity is expected to be experienced by any population. As with other spring migrants, water quality is also unlikely to be reduced by the proposed action during the winter and spring months. There is the potential for safe passage through barriers to be affected by reduced spill at Bonneville Dam for an Upper Gorge population. Adult migration, spawning, and rearing occur during the late fall and early winter, when the proposed action provides higher flows than those associated with the reference operation. Therefore, there is likely to be either no change or an improvement in functioning of spawning and incubation habitat for the mainstem populations.

Hydropower operations affect the quantity and quality of and access to spawning habitat in the Ives Island area below Bonneville Dam, where several early fall-run chinook salmon from the LCR ESU were observed spawning during October 1999. Spill operations at Bonneville Dam, such as spill for debris removal, gas generation/abatement testing, or juvenile fish passage, could create TDG concentrations high enough to kill yolk sac fry in redds in the Ives Island area. This effect can be prevented by providing flows that create a compensation depth over the redds and/or by reducing the effective TDG concentration to 105% of saturation or less. Flow fluctuations can strand subyearling migrants, making them vulnerable to desiccation or avian predation. Both flow and spill operations at Bonneville Dam have been managed to protect chum salmon since 1999. Beginning approximately November 1, the Action Agencies provide some operations to maintain minimum tailwater elevations at Bonneville to establish and protect redds, although the extent of these operations depends on the hydrologic forecasts and the ability to implement other seasonal operations. Efforts are made to limit spill to a level that would not exceed 105% over established redds. These efforts to protect chum salmon also confer protection on established LCR chinook redds and emergent fry.

Rearing habitat is likely to be unaffected by the proposed action during the spring. To the extent that CR chum salmon rear in the estuary during the summer, when proposed flows would be significantly lower than reference operation flows, the amount of available shallow-water habitat would be slightly but significantly reduced by the lower summer flows under the proposed operation. Juvenile chum salmon have a high reliance on shallow-water rearing habitat in the Columbia River estuary (Fresh *et al.* 2004). Any difference in the number of adults returning to their natal spawning areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, will be proportional to this effect.

6.13.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival

6.13.1.2.1 Effect of Proposed Hydro Operations and 2004, 2010 and 2014 System Configuration. There are no quantitative estimates of the effect of the proposed action on this ESU. If individuals emerge from an Upper Gorge population and migrate through Bonneville pool and dam, they could experience mortality within the range estimated for other ESUs, but this assumption and even the existence of an Upper Gorge population are very uncertain. Assuming the survival effect is similar to the effect on listed fall chinook, there would be a Medium reduction in survival for this population due to the proposed hydro operations and system configuration changes.

No difference in adult survival through Bonneville Dam and pool from the reference operation is expected as a result of proposed hydro operations (Appendix D, Attachment 4). However, if operations at Bonneville Dam cause juvenile mortality, an additional consequence is expected to be some difference in the number of adults returning to natal spawning areas and providing marine derived nutrients to the ecosystem compared to the reference operation. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of CR chum salmon is largely inferential, as discussed in Section 5.2.3.

6.13.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Based on the qualitative "habitat approach" and application of approximate survival estimates derived from other species to the individuals that migrate past Bonneville Dam, NOAA Fisheries concludes that the proposed action is likely to reduce abundance and productivity of CR chum salmon by a Very Low amount for lower river MPGs and possibly by a Medium amount for one population of the MPG that might migrate through Bonneville pool and dam. Because of the differential effect on various populations, the proposed operation also is likely to reduce distribution and diversity of the ESU.

6.13.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Based on the qualitative "habitat approach" and application of approximate survival estimates derived from other species to the individuals that migrate past Bonneville Dam, NOAA Fisheries concludes that the proposed action is likely to reduce abundance and productivity of CR chum salmon by a Very Low amount for lower river MPGs and possibly by a Low amount for one population of the MPG that might migrate through Bonneville pool and dam. Because of the differential effect on various populations, the proposed operation also is likely to reduce distribution and diversity of the ESU.

6.13.2 Effect of Non-hydro Measures

6.13.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.13.2.1.1 Enhance and Restore Estuarine Habitat. Columbia River chum salmon are small ocean-type migrants when they leave their spawning tributaries and enter the lower Columbia River. Expected benefits of the proposed estuary actions are the same as those described in section 6.6.2.1.1 for subyearling UWR chinook salmon, 0 short-term and Medium long-term (by 2014). This level of benefit will accrue to all of the populations in all of the major population groups.

6.13.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. NOAA Fisheries anticipates that there will be 0 short-term and Very Low long-term (by 2014) benefits to small subyearling CR chum salmon. This level of benefit will accrue to all of the populations in all of the major population groups. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.13.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies do not propose any non-hydro offsets in the tributaries affecting Columbia River chum salmon. NOAA Fisheries concludes no benefit to population or ESU viability from tributary non-hydro offsets for this ESU.

6.13.2.3 Effect of Artificial Propagation Measures

NOAA Fisheries notes that BPA funds a chum salmon program on Duncan Creek that will help reintroduce the species back into historical habitat. This will have a very minor benefit to the ESU by expanding to a minor extent the distribution of these fish.

6.13.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

6.13.3 Net Effect of Hydro and Non-hydro Actions

6.13.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.13.1 and 6.13.2 (Table 6.11).

6.13.3.1.1 Cascade and Coastal MPGs. These major population groups originate below Bonneville Dam and use the estuary for rearing. There is an unquantifiable Very Low effect of the proposed action on this MPG due to lower flows and slightly smaller rearing habitat under the proposed action, relative to the reference operation. The reduction in estuarine tern predation would result in a Very Low improvement, estuary habitat projects would result in a Medium improvement, and hatchery projects would result in a Very Low improvement for this MPG. Therefore, there would likely be no change to an improvement in the numbers, reproduction, or distribution of these MPGs as a result of the proposed action.

6.13.3.1.2 Gorge MPG. One of two populations in this major population group may originate upstream of Bonneville Dam and migrate past Bonneville dam. There is an unquantifiable Low negative difference due to lower reduced passage survival through the Bonneville project in the proposed action compared with the reference operation. Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have a Low positive effect for this MPG. The reduction in estuarine tern predation would result in a Very Low improvement for this MPG, and estuarine habitat projects would result in a Medium improvement by 2010. Therefore, it is possible that in the short term there would be a reduction for the one population that might migrate through Bonneville pool and dam, but it is likely that such a decrease will be balanced over time by an improvement in the numbers, reproduction, or distribution of this MPG as a result of the proposed action.

6.14 SNAKE RIVER SOCKEYE SALMON

6.14.1 Effect of Proposed Hydro Operations

6.14.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

Effects of the proposed action on habitat function are expected to be nearly identical to those described for SR spring/summer chinook salmon in Section 6.3. These effects are minor, except for safe passage past barriers, which is impaired by lower spill levels in the proposed hydro operation.

6.14.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival

6.14.1.2.1 Effect of Proposed Hydro Operations and 2004, 2010 and 2014 System Configuration. There are no quantitative estimates of the effect of the proposed hydro operation and system configuration changes on SR sockeye salmon. This ESU may experience mortality that is somewhat greater than the ranges estimated for SR spring/summer chinook salmon and SR steelhead, but this assumption is very uncertain, especially with regard to transportation effectiveness. The relative difference in survival between the reference and proposed operations is likely to be similar to that of the other two ESUs that migrate in the spring as yearlings, SR spring/summer chinook salmon and SR steelhead. Based on this range, there is likely to be, on average, a Low relative survival effect of proposed hydro operations and 2004 and 2010 system configuration compared to the reference operation. The additional fish passage configuration improvements, proposed to be implemented between 2010 and 2014 at FCRPS mainstem hydro projects, indicates there is likely to be, on average, a Low relative survival reduction to a slight survival improvement for juvenile SR sockeye by 2014.

No difference in adult survival is expected between the proposed hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). Any difference in the number of adults returning to their natal tributaries and providing marine derived nutrients to the ecosystem, compared to the reference operation, will be proportional to the relative system-survival gaps, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of SR sockeye salmon is largely inferential, as discussed in Section 5.2.3.

6.14.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative “habitat approach” and the quantitative “survival approach” leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of Snake River sockeye salmon by a Low amount for the single extant population in 2004-2014. It is not likely that the proposed action would reduce distribution or diversity of the ESU.

Under the “environmental baseline approach,” the proposed action is likely to negatively impact essential features of designated critical habitat during the entire period of the proposed action, but to a lesser extent during 2010-2014 than during 2004-2009. The essential feature of safe passage conditions in the juvenile migration corridor would be impaired compared to the reference operation, because the flows and spill rates through existing dams and reservoirs in the juvenile migration corridor would be lower in the proposed operation. Spill is generally a safer route of passage than other routes, as indicated by the difference in in-river survival estimates between the two operations (Tables 6.8, 6.9, and 6.10). As described in Section 6.14.1.1, water quality critical habitat essential features, such as temperature and dissolved gas concentration, are not likely to be affected by the proposed action. Similarly, differences in the functioning of critical habitat also are not expected for adult migration corridor features.

Under the "listing conditions approach," the proposed action is not likely to negatively alter essential features of critical habitat from conditions existing at the time of listing. The levels of safe passage in both 2004 – 2009 and 2010 – 2014 are higher than those in 1992, when this ESU was listed. See Section 5.2.2.1.1.

6.14.2 Effect of Non-hydro Measures

6.14.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.14.2.1.1 Enhance and Restore Estuarine Habitat. Like SR spring/summer chinook salmon, SR sockeye display a stream-type life history strategy (Fresh *et al.* 2004). As described in section 6.3.2.1.1, the magnitude, extent, and distribution of the proposed estuary actions are expected to provide 0 benefit to yearling migrants (in the case of SR sockeye, this level of benefit would apply to the single remaining population). The full benefit to be derived from these six projects will accrue over the term of the Biological Opinion. Thus, the proposed action for estuary habitat restoration will provide 0 short-term and 0 long-term (by 2014) benefits to SR sockeye salmon. This level of benefit will accrue to the single remaining population.

6.14.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. Because so few sockeye salmon reach the estuary, NOAA Fisheries anticipates that the proposed action will result in 0 short-term and 0 long-term (by 2014) benefits to yearling SR sockeye salmon migrants. This level of benefit will accrue to the single remaining population.

6.14.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies do not propose any non-hydro offsets in the tributaries affecting Snake River sockeye. NOAA Fisheries concludes no benefit to population or ESU viability from tributary non-hydro offsets for this ESU.

The Action Agencies' 2003 Progress Report identified habitat improvement actions that they had implemented under the 2000 RPA for the purpose of offsetting adverse hydropower impacts through at least 2010. Some of those actions were implemented in this subbasin. The Action Agencies will ensure these that actions are maintained so that benefits continue over the term of the UPA. NOAA Fisheries expects that some positive but currently immeasurable level of survival improvement, in addition to that derived from the conservation actions and measures detailed in the UPA, will accrue from each of these actions but has not attempted to quantify that benefit for the purpose of this analysis.

6.14.2.3 Effect of Artificial Propagation Measures

BPA has funded a safety-net program for Snake River sockeye salmon since 1991. This program has included captive broodstock rearing and research, genetic analysis, and habitat and limnological research. The Action Agencies are proposing to continue funding this safety-net program. The Action Agencies also propose to expand the current safety-net program by funding construction and operation of new hatchery facilities to produce smolts for release into the Stanley Basin Lakes. Specifically, the Action Agencies propose to fund needed construction and operational costs at Oxbow Hatchery near Bonneville Dam to produce up to 150,000 smolts.

The safety-net program has prevented likely extinction (60 FR 33102, June 14, 2004) of this ESU and remains very important to the ESU's continued existence. However, risks to all four VSP parameters (abundance, productivity, spatial structure, and diversity) are still very high, resulting in considerable uncertainty about its future viability. Nearly the entire ESU resides in the captive broodstock program, which has demonstrated limited success in returning anadromous adults. In 2000, over 250 anadromous adults returned to the Stanley Basin, most from a yearling smolt release. A consistent yearling smolt program has not occurred due to lack of dedicated rearing facilities and disease concerns, and anadromous adults have numbered fewer than 30 since 2001 (69 FR 33102, June 14, 2004). The longer this ESU relies on the captive broodstock program for its existence, the greater the risks associated with domestication and loss of genetic diversity, which will increase the difficulty of reestablishing a viable population in the ESU's native habitat. As indicated in Table 6.8, the current safety-net program is providing a Medium level of benefit by assuring the continued existence of the ESU, but the current benefit would likely lessen over time without a rapid increase in anadromous adults.

NOAA Fisheries agrees that a hatchery smolt program has the best potential for rapidly increasing the number of anadromous adults. Risks to all four VSP criteria remain high, and a rapid increase in the number of anadromous adults is needed to address these risks. If smolt-to-adult survival ranges from 0.1% to 0.3%, then the number of adult returns from a 150,000 smolt program would be expected to range from 150 to 450 adults returning to the Sawtooth Valley. The Action Agencies have identified a single production facility for the smolt program. There is a risk that the entire smolt production could be lost in any one year from mechanical malfunction or disease if only a single production facility is used

6.14.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate 0.6% change, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

As described in Section 6.3.2.4, the presence of dams and reservoirs in the environmental baseline provides good Northern Pikeminnow habitat, thereby reducing the "safe passage" essential feature of juvenile migration corridor critical habitat. The proposed action, which removes Northern Pikeminnow from the juvenile migration corridor, would improve the safe passage essential feature of juvenile migration corridor critical habitat.

6.14.3 Net Effect of Hydro and Non-hydro Actions

6.14.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.14.1 and 6.14.2 (Table 6.11).

During the entire duration of the proposed action, the proposed hydro operations are expected to result in lower survival of the single major population group of SR sockeye salmon. The proposed hydro operations and configuration changes are expected to result in an unquantifiable Low negative effect compared with the reference operation. NOAA Fisheries used the range of quantitative estimates for other spring-migrating salmon and steelhead to inform the magnitude of the impact. As indicated by comments received on the August 2004 draft of this Opinion, NOAA Fisheries acknowledges that the survival rate of SR sockeye salmon may be lower than that of other species, but whether this would result in a larger proportional difference between the proposed and reference operation is unknown. Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have a Low positive effect, as described in Section 6.14.2.4. Continuation and expansion of the captive broodstock program is expected to have a Medium positive effect, as described in Section 6.14.2.3. The combination of all proposed actions is likely to result in an improvement in the abundance, productivity, or distribution of this ESU.

6.14.3.2 Net Effect on Essential Features of Critical Habitat

The net effect of the proposed action is to negatively affect an essential feature of designated critical habitat using the "environmental baseline approach." As described in Section 6.14.1.3, the "safe passage" essential feature in the juvenile migration corridor is likely to be impaired, compared to the reference operation, because the spill rates and flow velocities are lower in the proposed operation. The magnitude of the impairment is significant between 2004 and 2009, as indicated by the range of in-river survival reduction relative to the reference operation (Table 6.8). The magnitude is smaller by 2010 to 2014 in response to hydro passage improvements. Under the most optimistic assumption, there is no reduction in in-river survival between the reference and proposed operation (Tables 6.9 and 6.10). However, NOAA Fisheries must consider the full range of assumptions in making a determination. The immediate expansion of the pikeminnow removal program (6.14.2.4) partially offsets this adverse effect. This is only a partial offset because, to the extent that safe passage habitat conditions can be evaluated by the survival rate of fish through that habitat, the magnitude of the survival improvement associated with the pikeminnow program in the proposed action is less than the magnitude of the survival reduction associated with the proposed spill operation, except under the most optimistic assumptions for 2010 and 2014.

To the extent that juvenile mortality in the hydrosystem causes some difference in the number of adult SR sockeye salmon returning to their natal tributaries, it will affect nutrient cycling in spawning and rearing areas compared to the reference operation. Because functional and quantitative relationships between returning adults, marine derived nutrients, and essential features of critical habitat are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for habitat designated as critical for SR sockeye salmon is largely inferential, as discussed in Section 5.2.3.

Under the “listing conditions approach,” there is no negative alteration of critical habitat, because the conditions of essential features resulting from the proposed action will be better than those existing at the time of listing. See Section 5.2.2.1.1.

6.15 LOWER COLUMBIA COHO SALMON

6.15.1 Effect of Proposed Hydro Operations

6.15.1.1 Effects of Proposed Hydro Operations on Mainstem Habitat Conditions, Including in the Estuary and Plume

The primary estuary and plume habitat changes associated with proposed hydro operations are expected to be very similar to those described in Section 6.3 for SR spring/summer chinook salmon.

6.15.1.2 Effect of Proposed Hydro Operations on Juvenile and Adult Mainstem Reach Survival

6.15.1.2.1 Effect of Proposed Hydro Operations and 2004 System Configuration. Most LCR coho originate below Bonneville Dam and do not migrate through any hydro projects. However, two of three populations in one of the two major population groups (Upper Gorge) migrates through Bonneville Dam and pool. No empirical survival rate estimates exist for this ESU. No change in survival is expected for the populations originating below Bonneville Dam. For the two populations that originate above Bonneville Dam, the survival rate is likely to be similar to that of other yearling juveniles that migrate through Bonneville Dam and pool during the spring. Assuming that the survival rate ranges between that of LCR chinook and LCR steelhead, the difference in juvenile survival between the proposed and reference operations would be -1.6 to -2.8% in 2004 (Table 6.8; Appendix D).

No difference in adult survival through Bonneville Dam and pool between the proposed 2004 hydro operation and the reference operation is expected as a result of proposed hydro operations (Table 6.4; Appendix D, Attachment 4). However, an additional consequence of juvenile mortality is expected to be some difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem compared to the reference operation. The difference is proportional to the relative system-survival gap for 2004, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR coho salmon is largely inferential, as discussed in Section 5.2.3.

6.15.1.2.2 Effect of Proposed Hydro Operations and 2010 System Configuration Improvements. The proposed intermediate-term hydro improvements and operations would reduce the relative survival difference, compared to the reference operation, to -1.4 to -2.4% for the two LCR coho populations that migrate through Bonneville Dam and pool (Table 6.9; Appendix D, Attachment 4).

No difference in adult survival is expected between the proposed 2010 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative 2010 system-survival gap, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR coho salmon is largely inferential, as discussed in Section 5.2.3.

6.15.1.2.3 Effect of Proposed Hydro Operations and 2014 System Configuration Improvements. The proposed long-term hydro improvements and operations would reduce the relative survival of the two LCR coho populations that migrate through Bonneville Dam and pool, compared to the reference operation, by an average of -0.8 to -1.8% (Table 6.10; Appendix D). The substantial reduction in the relative in-river survival gap for LCR coho in the long term is due to various fish passage improvements made at both Bonneville Dam powerhouses to increase bypass survivals, as described in Section 6.3.1.2.3 for SR spring/summer chinook salmon.

No difference in adult survival is expected between the proposed 2014 hydro operation and the reference operation (Table 6.4; Appendix D, Attachment 4). The difference in the number of adults returning to their natal spawning and rearing areas and providing marine derived nutrients to the ecosystem, compared to the reference operation, is proportional to the relative 2014 system-survival gap, described above. Because functional and quantitative relationships between returning adults, marine derived nutrients, and juvenile survival are poorly understood, it is difficult to generalize from the specific conditions that have been studied. The evidence that the effect is significant for any given population of LCR coho salmon is largely inferential, as discussed in Section 5.2.3.

6.15.1.3 Qualitative Characterization of All Effects of Proposed Hydro Operations and Configuration Changes

Application of the combined qualitative “habitat approach” and the quantitative “survival approach” leads NOAA Fisheries to conclude that the proposed action is likely to reduce abundance and productivity of LCR coho by a Medium amount for the two populations originating upstream of Bonneville Dam and by a Very Low amount for all other populations.

Because of the differential effect on various populations, the proposed operation also is likely to reduce distribution and diversity of the ESU.

6.15.2 Effect of Non-hydro Measures

6.15.2.1 Effect of Measures to Protect, Enhance, and Restore Estuarine Habitat and to Reduce Predation in the Estuary

6.15.2.1.1 Enhance and Restore Estuarine Habitat. Like SR spring/summer chinook salmon, LCR steelhead display a stream-type life history strategy (Fresh *et al.* 2004). As described in section 6.3.2.1.1, the magnitude, extent, and distribution of the proposed estuary actions are expected to provide 0 benefit to yearling migrants (in the case of LCR coho, this level of benefit would apply to all the populations and major population groups).

6.15.2.1.2 Reduction in Caspian Tern Predation Rates in the Estuary. The Action Agencies' proposed action for reducing predation rates by Caspian terns nesting in the estuary is described in section 6.3.2.1.2. Based on the projected levels of tern colony size resulting from implementation of alternatives C and D of the draft EIS, NOAA Fisheries estimates level of benefit for LCR steelhead as approximately 0 short-term and Medium long-term (by 2014) benefits (i.e., a 5% relative increase in survival) to LCR coho. This level of benefit will accrue to all of the populations in all of the major population groups. The Action Agencies' assessment of the benefit (increased survival) to this ESU that would result from reduced tern predation relies on an assumption of no compensatory mortality. Although some level of compensatory mortality is likely to occur, there are no existing data from which to estimate the appropriate value or range (Roby *et al.* 2003). In the absence of an estimate of compensatory mortality, NOAA Fisheries evaluated the sensitivity of the projected benefit from reduced tern predation under differing scenarios of compensatory mortality (Appendix E). Based on that evaluation, compensatory mortality would need to exceed 50% to reduce the contribution of offsetting actions towards filling the hydrosystem survival gap below that estimated by the Action Agencies in their BA. NOAA Fisheries believes that the estimated benefit from reduced tern predation on this ESU is robust across a wide range of estimates of compensatory mortality.

6.15.2.2 Effect of Measures to Protect, Enhance, or Restore Tributary Habitat

The Action Agencies do not propose any non-hydro offsets in the tributaries affecting Lower Columbia River coho salmon. NOAA Fisheries concludes no benefit to population or ESU viability from tributary non-hydro offsets for this ESU.

6.15.2.3 Effect of Artificial Propagation Measures

The Action Agencies are proposing no artificial production measures to improve survival of LCR coho salmon.

6.15.2.4 Effect of Measures to Reduce Fish Predation

As described in Section 6.3.2.4, the ongoing NPMP is already accounted for in the estimation of the survival difference between the proposed action and the reference operation. The expected survival improvement from the expanded NPMP would be an immediate change of less than 1%, based on the Action Agencies' calculations, but see discussion of comments on this calculation in Section 6.3.2.4. In summary, the expanded NPMP would result in a Low improvement.

6.15.3 Net Effect of Hydro and Non-hydro Actions

6.15.3.1 Net Effect on Abundance, Productivity, and Distribution

NOAA Fisheries considered the net effect of the proposed hydro operations, proposed hydro configuration changes, and offset actions, as described in Sections 6.12.1 and 6.12.2 (Table 6.11).

For all populations that originate below Bonneville Dam and rear primarily in streams, there is a Very Low negative difference between the proposed action and the reference operation for these MPGs. The reduction in avian predation by 2010 is expected to result in a Medium improvement for this MPG. Therefore, it is likely that there would be no net difference and, over time, an improvement in the numbers, reproduction, and possibly distribution of these MPGs as a result of the proposed action.

For the two populations that originate upstream of Bonneville Dam and migrate through Bonneville pool and dam, there is likely to be a Medium negative difference due to lower passage survival through Bonneville. No difference in adult survival through Bonneville Dam and pool from the reference operation is expected as a result of proposed hydro operations (Appendix D). Continuation and expansion of the Northern Pikeminnow Management Program is estimated to have an immediate Low positive effect for this MPG and ongoing hatchery programs are expected to have a Very Low effect. The reduction in avian predation by 2010 is expected to result in a Medium improvement for this MPG. Therefore, it is likely that there would be a reduction from 2004-2009 and no net difference and possibly an improvement by 2010 in the numbers, reproduction, or distribution of this MPG as a result of the proposed action.